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LATIN AMERICA AND THE CARIBBEAN: INVENTORY OF WATER RESOURCES AND THEIR USE

Volume I

MEXICO, CENTRAL AMERICA AND THE CARIBBEAN

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INTRODUCTION

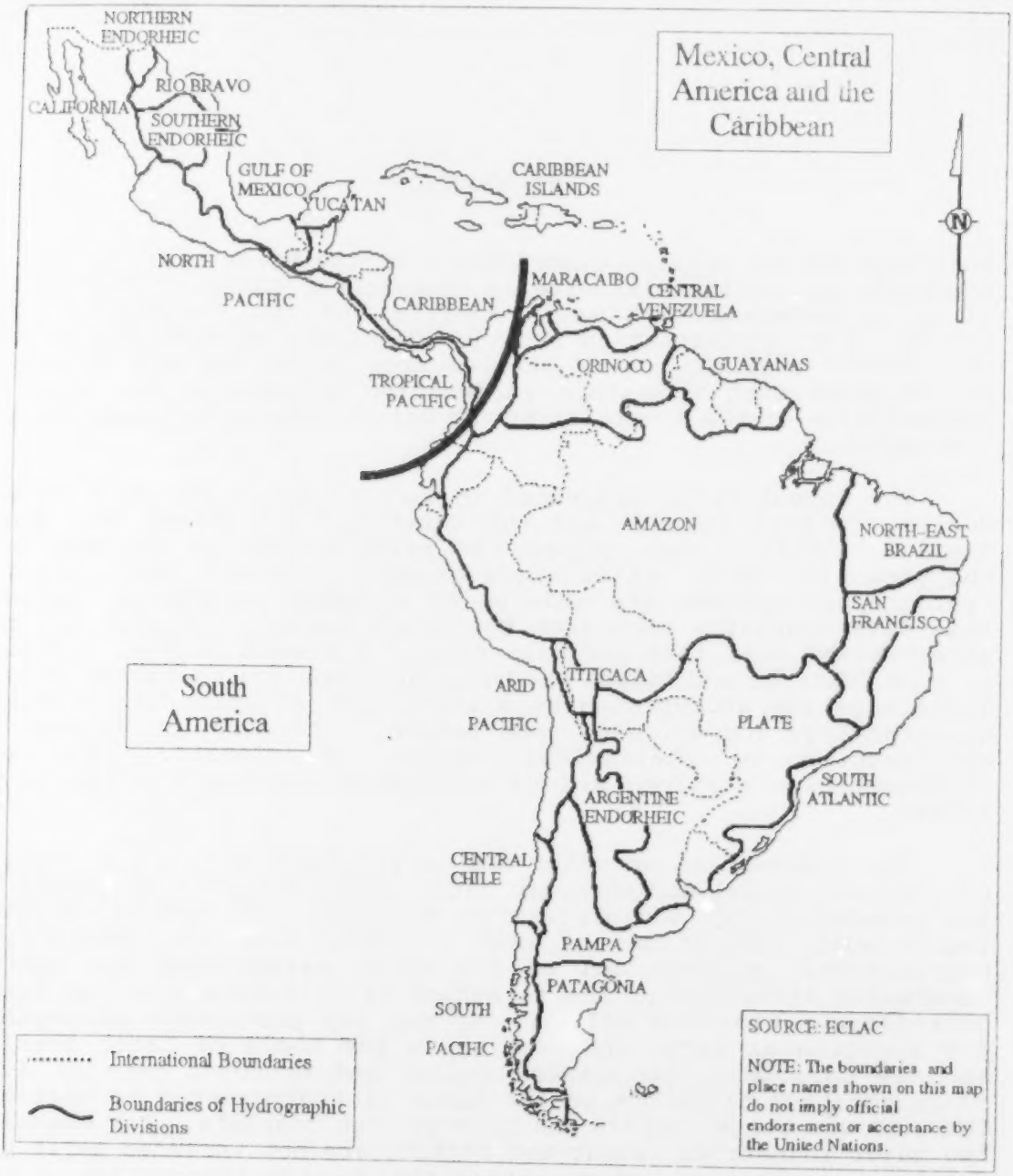
Knowledge of the spatial distribution of the water resource and of the human use of that resource is fundamental for an understanding of water management in Latin America and the Caribbean. The purpose of this publication is to provide basic information on both the natural availability of the resource and on the use of water. It is hoped that from this information the reader can gain an appreciation of the diversity of the water management issues facing the region.

The inventory is presented in two volumes. Volume I covers Mexico, Central America and the Caribbean and Volume II, South America. Within each volume the presentation is divided into chapters on each major hydrographic region (see map 1). Hydrographic systems are made up of a number of smaller basins; this differentiates them from the major basins, in which all the watercourses flow into one main river. For each region, a series of maps describe and locate the basic geographical characteristics. These maps are accompanied by a short text covering the climate, geomorphology and soils of each region. The descriptive text is supplemented by statistical tables of climatic data for representative stations and of average streamflow for the major rivers.

The information on water use is provided in a set of tables of relevant social and economic data. These tables supply data on the population by administrative division, the cities in each region with populations of over 100 000, dams and reservoirs, hydroelectric plants, and on the major water-using and waste-generating industries. The formation of this data base has taken considerable time and effort. No one has previously attempted, for a region as large and complex as the whole of Latin America and the Caribbean, to present social and economic data or even administrative divisions on the basis of hydrographic boundaries. The work was begun in 1975 and is still not complete. For example, two major industries, sugar and coffee, are not included as it has not been possible as yet to obtain region-wide information on the location of individual plants.

Map 1

LATIN AMERICA AND THE CARIBBEAN: MAIN HYDROGRAPHIC DIVISIONS



From the beginning of this work, the intention has been to keep the data files on water use constantly updated. For this reason, the basic information is kept in computer files. This not only permits rapid and easy updating, but allows the manipulation of the basic records to support specific applications of the data.

Water use in Latin America and the Caribbean

Latin America is the most humid of the regions of the world, but it contains some of the most arid areas on earth. South America, with a mean annual precipitation of 1 560 mm, has the highest rainfall and runoff of any continent. There are, however, some very arid areas. The Atacama desert, in northen Chile, is the driest region on the globe. These contrasts in the physical availability of water, coupled with the variations in the density of human settlement, produce strongly contrasting patterns of use and transformation of the water resource.

The use of the water resource by man varies even more greatly than the availability of the resource. Latin America exhibits striking differences in the nature of human activities and in the density of settlement. Vast areas of the region are still relatively undisturbed, almost half of which is still classified as forest and woodland. There are also, however, industrial regions of global significance which have some of the largest concentrations of urban population to be found anywhere.

The main orographic system of Latin America, the Andes mountain chain, gives rise to three main types of hydrologic systems: the large river systems flowing to the Atlantic Ocean and adjacent seas; the short streams of the Pacific watershed and the intermittent streams of the areas of internal drainage.

The Atlantic basins are the most extensive (84% of the total land area), and the three largest systems, the Orinoco, the Amazon and the Plate, account for two-thirds of total streamflow. They are characterized by slight gradients and the rivers maintain relatively steady flows in the lower reaches. There are broad floodplain areas subject to extensive regular flooding, as in Paraguay and Argentina.

In contrast, the Pacific basins, accounting for 11% of the total area, have steep gradients, and the rivers have marked variations in flow. The areas of internal drainage (some 5% of the total area) are mainly in the high central Andean plateau, in the Argentine interior and in northern Mexico, and exhibit very irregular patterns of flow.

The overall pattern of water use in Latin America and the Caribbean is spatially sporadic and highly concentrated. Much of the water use is concentrated in coastal areas and therefore has

only a limited impact on the major drainage systems. Where drainage systems are influenced by man, the major effects have arisen from changes in land use and from the deliberate regulation of stream flow through the construction of dams and, to a lesser extent, through interbasin diversions. Regulation of streamflow on a large scale is mainly a characteristic of the last fifty years, while changes in the patterns of land use have been significant since the time of the earliest human settlements and remain, perhaps, the more important means by which human activities affect hydrographic patterns in the region.

Patterns of land use

The gross domestic product of Latin America has grown at an average annual rate of almost 5 percent for much of the last four decades. Even more important than this growth, however, from the point of view of water use, have been the changes in the internal structure of the economies of the region. Much of the change has been in the direction of the increasing importance of manufacturing industry and services in contrast to primary production, both agriculture and mining. Latin America is, however, the one region of the world where the agricultural frontier continues to expand and many hydrographic regions remain predominantly agricultural (see table 1). The area defined as arable land and pastures expanded at ten times the global rate between 1970 and 1985, and large areas have been deforested in recent years. In Central America, 15 percent of the forest and woodland existing in 1970 was felled during that decade. Similarly high rates of deforestation are found in the Amazon basin.

At the same time, the proportion of the area cultivated under irrigation has increased. More than one-third of the total area under irrigation is found in Mexico. Irrigation there, as in the other traditional areas of irrigated agriculture (Peru, the central valley of Chile, and adjacent areas of Argentina), predates the arrival of the Spanish. The greatest increases in irrigation in the last two decades have been in parts of central and southern Brazil, in Central America and in Cuba.

The regulation of streamflows

The early development of irrigation involved, at least locally, the regulation of streamflows. Large dams did not make their appearance, however, until late in the colonial period. The earliest existing large dam was built on the Saucillo river in Mexico in 1750 to provide irrigation, and irrigation has remained

Table 1

LATIN AMERICA AND THE CARIBBEAN: DISTRIBUTION OF HUMAN ACTIVITY BY MAJOR HYDROGRAPHICH SYSTEM

Hydrographic system	Area km2	Population 1960	Population 1970	Population 1980	Density 1980	Annual avg. percentage increase (1960-1980)	GDP 1980 (millions of 1980 US dollars)	GDP 1985 (millions of 1980 US dollars)	% GDP Agric.	% GDP Indus.	% GDP Serv.
CENTRAL AMERICA & THE CARIBBEAN											
California	471 473	2 820 032	4 132 946	5 739 565	12.17	3.62	15 100.8	16 620.4	16.2	20.9	63.0
Caribbean	646 213	16 840 767	22 384 393	28 497 374	44.10	2.66	32 857.4	36 332.2	22.5	24.8	52.6
Caribbean Islands	230 789	20 328 660	24 430 255	30 044 411	130.18	1.97	55 517.0	63 565.5	12.7	33.7	53.6
Gulf of Mexico	474 552	19 724 062	28 113 599	39 783 373	83.83	3.57	109 288.7	120 005.2	8.5	35.4	56.1
North Pacific	328 406	8 121 876	10 618 230	13 820 162	42.08	2.69	26 095.6	28 673.9	19.6	21.8	58.6
Northern Endorheic, Mexico	140 840	699 272	919 139	1 143 122	8.12	2.49	2 807.6	3 090.2	19.5	27.6	52.8
Rio Bravo	214 096	1 621 683	2 243 483	3 112 607	14.54	3.31	10 672.9	11 747.0	8.5	44.0	47.5
Southern Endorheic, Mexico	236 637	2 257 220	2 829 615	3 727 082	15.75	2.54	8 493.3	9 348.0	35.4	23.9	40.7
Yucatan	141 523	832 437	1 098 061	1 710 271	12.08	3.67	3 518.4	3 872.4	17.0	26.6	56.4
SOUTH AMERICA											
Amazonas	6 157 253	10 414 471	13 684 801	18 416 972	2.99	2.89	19 242.7	19 924.1	22.9	22.1	55.0
Central Chile	116 002	5 466 021	6 809 934	8 324 396	71.76	2.13	18 245.3	18 022.3	7.6	36.8	55.6
Central Venezuela	142 419	4 356 758	6 346 751	8 661 137	60.81	3.50	30 562.5	28 189.1	7.0	29.8	63.2
Guayanas	468 235	895 431	1 149 533	1 186 631	2.53	1.42	1 702.0	1 655.0	14.8	35.3	49.9
Endorheic, Argentina	706 869	3 923 597	4 405 305	5 333 450	7.55	1.55	11 556.8	10 127.7	19.4	27.8	52.8
Maracaibo	101 688	2 450 814	3 296 334	4 114 182	40.46	2.62	12 062.3	11 265.3	8.2	29.3	62.5
North-east Brazil	881 361	12 415 643	15 647 407	19 175 848	21.76	2.20	13 284.2	14 466.3	18.2	16.0	65.8
Orinoco	1 116 599	3 490 445	4 475 929	5 646 580	5.06	2.43	12 278.3	12 069.5	19.0	27.1	53.9
Pacific: Arid Climate	590 419	6 630 031	9 575 465	12 795 372	21.67	3.34	19 070.3	18 977.5	10.7	41.5	47.8
Pacific: Tropical Climate	348 495	12 840 420	17 273 856	21 506 679	61.71	2.61	26 547.9	28 283.2	28.8	22.9	48.3
Pampa	621 207	2 347 099	2 887 705	3 666 148	5.90	2.25	9 896.1	8 672.4	14.9	45.8	39.3
Patagonia	487 645	201 851	285 909	402 784	0.83	3.51	1 691.3	1 482.1	14.5	49.6	35.9
Plate	3 878 926	42 987 903	56 231 529	70 061 929	18.06	2.47	204 115.6	207 430.0	11.3	37.1	51.6
Sao Francisco	617 778	10 758 761	13 051 100	15 607 537	25.26	1.88	20 445.7	22 265.0	17.6	21.7	60.7
South Atlantic	795 875	16 634 026	20 799 476	30 500 661	38.32	3.08	73 943.9	80 471.3	9.5	26.9	63.6
South Pacific	343 471	1 405 130	1 564 822	1 736 796	5.06	1.07	2 698.6	2 664.7	27.0	18.0	55.0
Titicaca	112 501	753 130	912 488	1 089 602	9.69	1.86	671.3	619.0	17.7	34.6	47.7
TOTAL LATIN AMERICA	20 371 272	211 217 540	275 168 065	355 804 671	17.47	2.64	742 366.5	779 839.3			

Sources: GDP 1980 and 1985: ECLAC, Statistics Division, national accounts (computer printout), 1988.
GDP Caribbean Islands and Guayanas: United Nations, National Accounts Statistics: Analysis of Main Aggregates, 1982 (ST/ESA/STAT/SER.X/2), New York, 1985, Sales No. E.85.XVII.4.
Population and Area: National censuses and United Nations Statistical Yearbook.
Structure of GDP: ECLAC and national reports.
GDP by sector: Economic Commission for Latin America (ECLA), Distribución regional del producto interno bruto sectorial en los países de América Latina, Cuadernos Estadísticos de la CEPAL series, No. 6, (E/CEPAL/G.1115), Santiago, Chile, 1981.

Notes:
1. Year for the structure of GDP by country: Argentina 1968/Brazil 1980/Chile 1980/Colombia 1975/Ecuador 1965/Panama 1968/Peru 1980/Mexico 1980/Uruguay 1961.
2. The regional distribution of GDP for Bolivia, Costa Rica, Guatemala, Honduras, Nicaragua and Venezuela has been calculated in proportion to the distribution of population in 1980 by administrative region, and the base of national GDP.

the major purpose of the greatest number of dams ever since. With increasing industrialization, hydroelectricity power generation has become a significant secondary purpose and, in general, the dams built for this purpose provide greater storage (see figure 1).

Originally, regulation was restricted to smaller streams. The growth in the number of reservoirs and dams since 1950 has, however, led to the regulation of the large river systems draining into the Atlantic Ocean, particularly the Plate basin. Almost the total storage constructed since 1976 (120 111 022 000 cubic metres) has been in that basin.

Despite the growth in the regulation of streamflows in Latin America and the Caribbean, most river systems are still largely uncontrolled. Human influence on water flows continues to be exercised chiefly through the changes induced in vegetation cover, and it seems unlikely that this situation will change in the immediate future. The agricultural frontier continues to expand despite the decline in the relative size of the rural population.

The large metropolitan areas and some industries have a very significant influence on flow patterns and even more so on water quality, but in terms of the region as a whole the impacts are very localized. Industrial and urban activities are heavily concentrated in a few basins. The rate of dam building remains high, despite the hiatus induced by the debt crisis in many countries of the region, and the number of regulated streams continues to grow. Nevertheless, the wide variation in the intensity of use of the water resource is likely to remain characteristic of the region for many years to come.

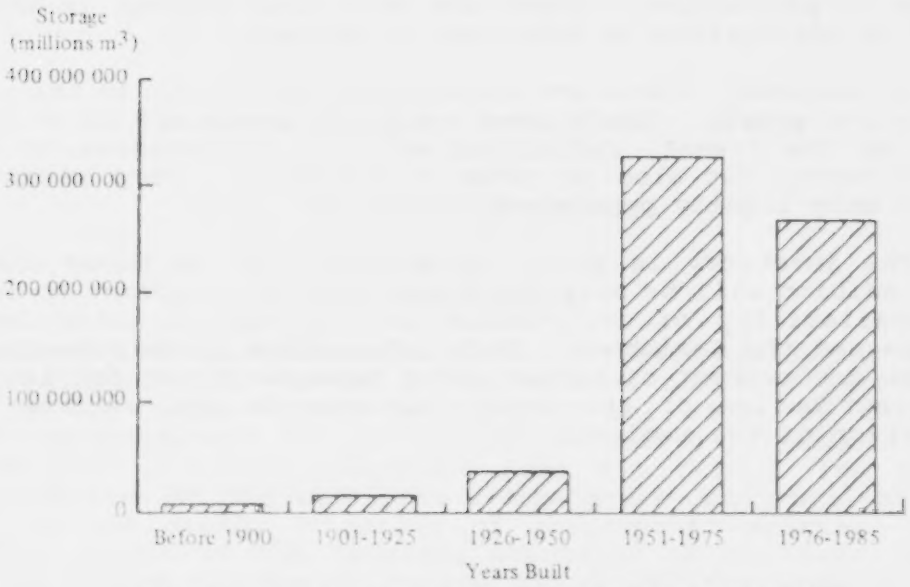
The distribution of human activity in relation to hydrographic boundaries

In order to provide a more complete picture of the relationship between the water resources of the region and human activities, an attempt has been made to present some basic indicators on the basis of river basin boundaries (see table 1). In constructing this table, various suppositions had to be made in assigning population and gross national product to a particular basin. It is necessary, therefore, to treat the resulting tabulations with considerable caution, although for comparative purposes the relationships are probably in the correct order.

The distribution of both population and economic activity is notable unequal, with high concentrations in three of the 26 major hydrographic divisions: the Gulf of Mexico, South Atlantic and Plate basins. These three basins account for 52 percent of the total gross domestic product of the region and are home to almost 40 percent of its population.

Figure 1

LATIN AMERICA: STORAGE BEHIND LARGE DAMS



Source: International Commission on Large Dams (ICOLD), *World Register of Dams*, Paris, 1984.

The considerable variation in the location of activity is accompanied by smaller differences in the structure of activities among the various basins. In most of the region, services and industry are the dominant sectors, although with differing relative shares of production. There are only five regions in which the share of agriculture is more than 20 percent.

In contrast, there are significant variations in the rates of population growth. The highest rates of growth are three times as great as the lowest, reflecting not only differences in natural growth rates, but also in rates of migration. Many river basins remain only lightly populated.

The inventory is still incomplete. It is hoped that this first edition will be only the first step in an effort to increase the availability of information on the use of water in Latin America and the Caribbean. Such information is an essential tool for the achievement of better water management and for maximizing the contribution of the water resource to the welfare of the population of the region.

I. NORTHERN ENDORHEIC HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The Northern Endorheic watershed is the drainage system for an area of approximately 140 840 km^2 in the extreme north of Mexico. It takes in the north-western portion of the State of Chihuahua between approximately 31° 45' anf 28° 30' north latitude and 108° 50' and 105° 15' west longitude (see map 1.1). Its natural boundaries are: on the west, the Sierra Madre Occidental mountain range; on the south, a series of transversal mountain chains extending across to the Tasajera mountains in the east; on the east, the Sierra del Hueso; and on the north, the lower-altitude central high plateau (the northern boundary corresponds to the United States border).

The three major endorheic watercourses are the Casas Grandes River, which flows into Lake Guzmán; the Santa María River which drains into Lake Santa María; and the Carmen River, which flows into Lake Patos.

2. Climate

a) Climate types (Köppen classification): The entire region is extremely arid, with a dry climate (type B) that can be divided into two subtypes: desert (BW) and steppes (BS). The latter is confined to the south-western part of the system on the eastern slope of the Sierra Madre Occidental where the upper courses of the main rivers are located. The area becomes progressively more arid towards the north and north-east as one approaches the lower courses of the rivers, where a dry and hot desert climate (BWh) predominates (see map 1.2).

b) Precipitation: Precipitation is very low throughout the system, ranging from less than 200 mm per year in a small depression near Lake Santa María up to 700 mm per year near the western boundary of the system in the Sierra Madre Occidental. In about 70% of the zone the mean annual precipitation varies between 200 and 400 mm (see map 1.3 and table 1.1).

c) Temperature: Mean annual temperatures in this zone vary between 12°C and 17°C depending upon the altitude. Daily temperature variations between night and day and annual variations between summer and winter are very marked. Mean annual temperature patterns follow the altitude curves and, generally speaking, are higher in the most arid portion of the zone in the north-east (see table 1.1).

3. Geomorphology and soils

The Northern Endorheic hydrographic system is part of the Mexican high plateau which stretches between the Sierra Madre Occidental and the Sierra Madre Oriental. This plateau is formed by fill, and its rivers drain into inland lakes. The source of the fill is the long-standing natural weathering process affecting the mountain chains and ranges constituting the boundaries of this hydrographic system.

The relief of the land is hilly in the south-western and western portions, with spurs running towards the north and north-east, along with some inselbergs on the plains which extend up to the United States border.

Due to the climatic characteristics and the endorheic nature of the area, there are a number of ephemeral and subsurface streams which flow into small lakes or groundwater reservoirs whose levels are regulated by the rapid rate of evaporation and the high permeability of the soils.

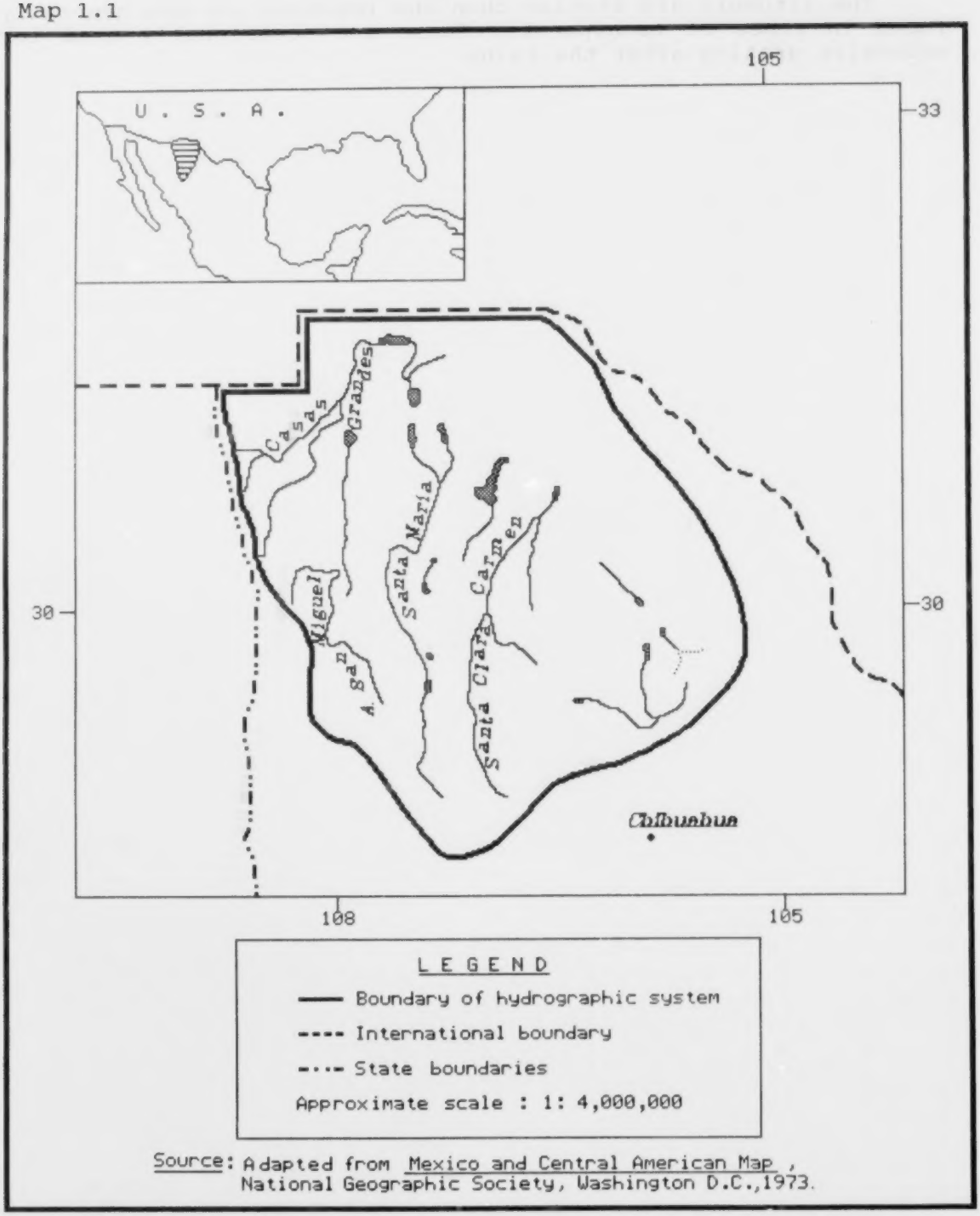
The soils of the region (kastonozems, xerosols and yermolsols) suffer from salinization and calcification, where irrigation is possible but not well managed, and from a low water retention capacity and an insufficiency of organic material (regosols and litosols) (see map 1.4). Within the region, the kastanozems are found in the mountainous and hilly zones appropriate only for extensive grazing. The xerosols have a high content of nutrient elements, but these rarely can be assimilated by plants if there is not well managed irrigation. Therefore, these soils, too, are principally used for extensive grazing.

The yermosols, even more arid and poor than the xerosols, demand careful irrigation management, where possible, due to clay or cemented horizons very close to the surface. These soils only allow occasional extensive grazing after the rains.

The regosols are formed from sands and fine aeolic sediments (slightly saline) which accumulate intermittently. Their porosity and exposure to wind erosion makes them little apt for any type of agricultural use.

The litosols are stonier than the regosols and are generally found in zones of escarpments. These are occasionally used for extensive grazing after the rains.

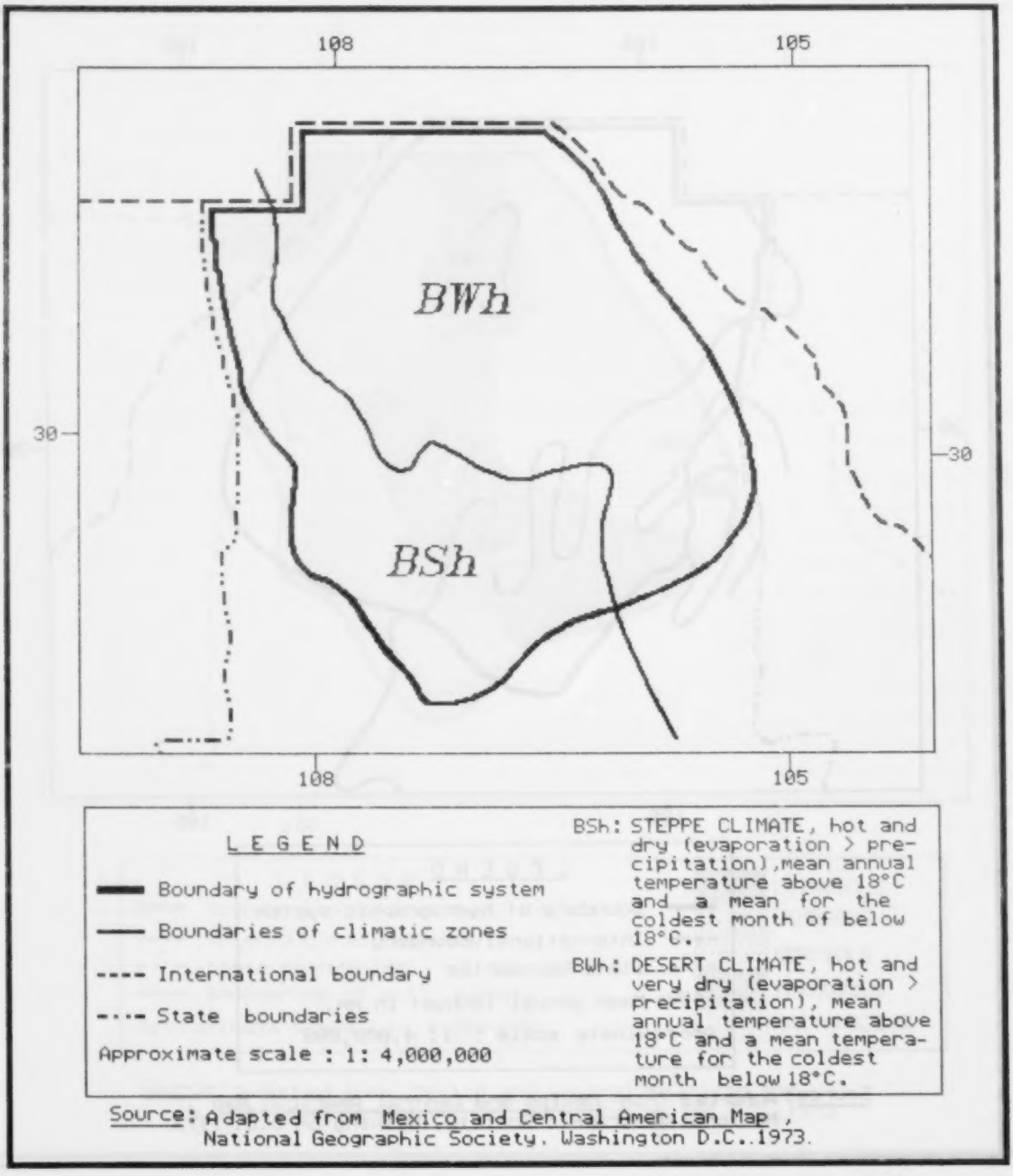
Map 1.1



Source: Adapted from Mexico and Central American Map , National Geographic Society, Washington D.C.,1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 1.2



LEGEND

- Boundary of hydrographic system
- Boundaries of climatic zones
- International boundary
- State boundaries

Approximate scale : 1: 4,000,000

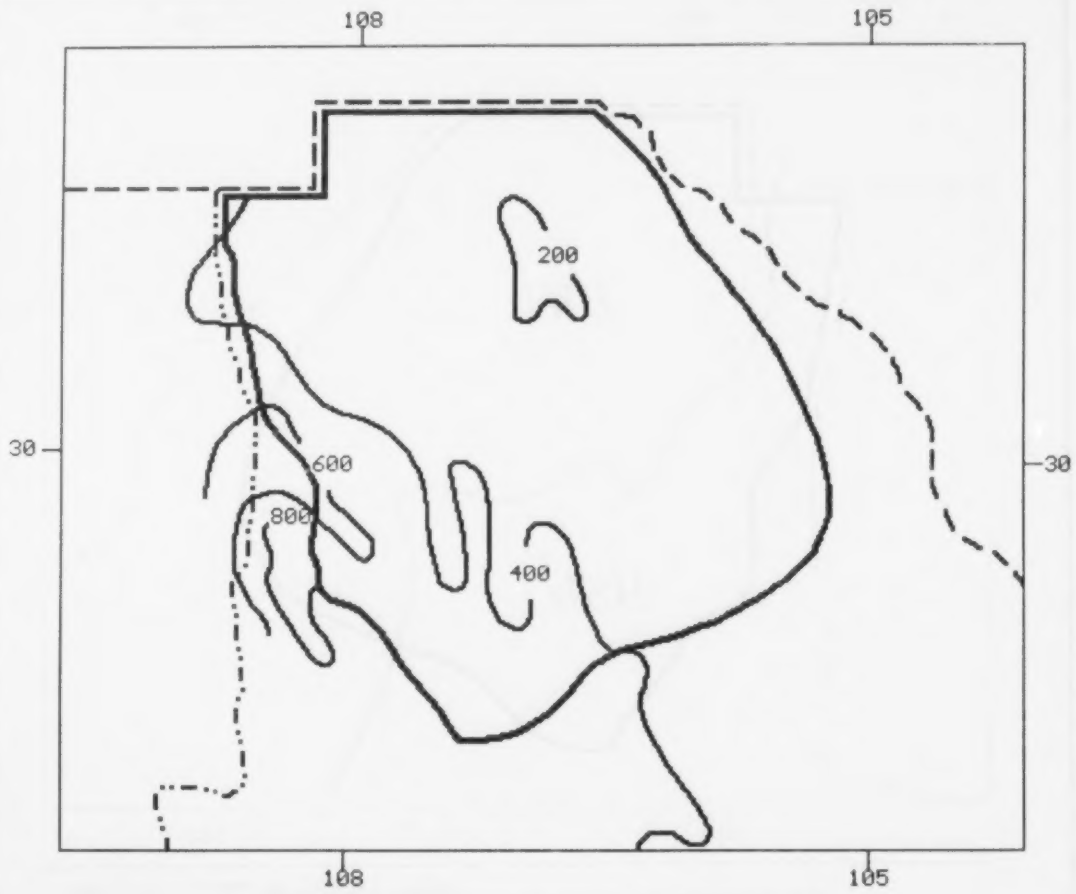
BSh: STEPPE CLIMATE, hot and dry (evaporation > precipitation), mean annual temperature above 18°C and a mean for the coldest month of below 18°C.

BWh: DESERT CLIMATE, hot and very dry (evaporation > precipitation), mean annual temperature above 18°C and a mean temperature for the coldest month below 18°C.

Source: Adapted from Mexico and Central American Map, National Geographic Society. Washington D.C..1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

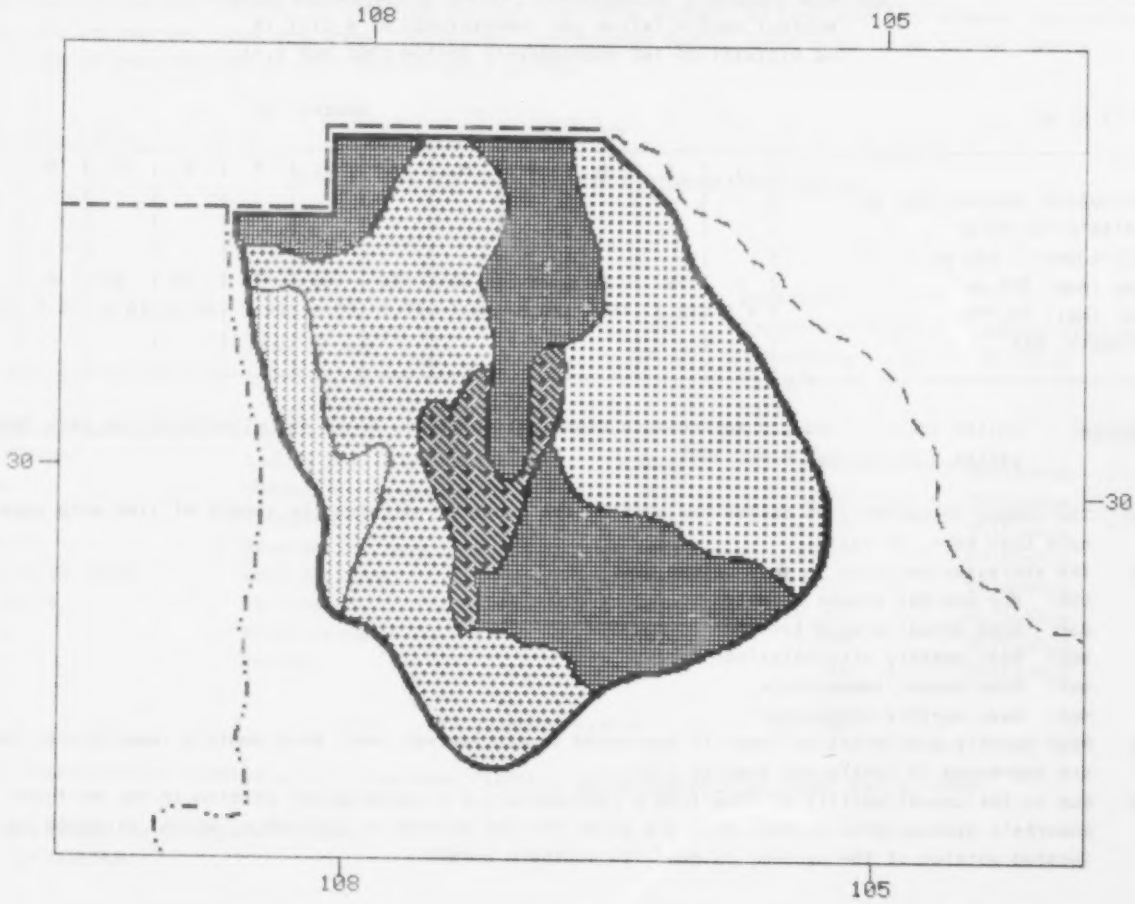
Map 1.3



Source: Adapted from Mexico and Central American Map , National Geographic Society, Washington D.C.,1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 1.4



Source: Adapted from Mexico and Central American Map , National Geographic Society, Washington D.C.,1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 1.1

NORTHERN ENDORHEIC HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT A CITY IN THE VICINITY OF THE HYDROGRAPHIC SYSTEM (SEE MAP 1.1)

City a/ b/	Months c/											
	J	F	M	A	M	J	J	A	S	O	N	D
CHIHUAHUA, Mexico (56) d/												
28°38'N-106°05'W												
Altitudes: 1 423 m												
mmp (map: 350 mm)	7	5	5	5	11	34	86	86	72	22	9	8
mmt (mat: 18.7°C)	9.8	12.2	15.5	20.0	24.1	27.1	25.6	24.9	22.6	18.9	13.8	10.1
Climate: BSh												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

b/ The abbreviations used in this column are:
BSh: dry and hot steppe climate
map: mean annual precipitation
mmp: mean monthly precipitation
mat: mean annual temperature
mmt: mean monthly temperature

c/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

d/ Due to the unavailability of data from a representative climatological station in the Northern Endorheic hydrographic system, data are given for the station of Chihuahua, which, although it is located outside of the system, is near its southern border.

B. STATISTICAL DATA CONCERNING WATER USE

At the time of the publication, information was not available concerning hydroelectric plants, thermoelectric plants, oil refineries, iron and steel industries, non-ferrous metals industries or on cities having populations of over 100 000 in this hydrographic system.

Table 1.2

DAMS IN THE NORTHERN ENDORHEIC HYDROGRAPHIC SYSTEM

River	Name of dam	Year built	Reservoir Capacity (Thousands of m^3)	Purpose a/	Administrative division
(Mexico)					
Casas Grandes	Laguna Colorada	1966	9 000	I	Chihuahua
Galindo	Centenario de Juarez	1972	3 110	...	Chihuahua
Nueva Madera	Independencia	1962	4 550	I	Chihuahua
Papigochic	Abraham Gonzalez	1961	70 700	I	Chihuahua
San Pedro de Janos	Casa de Janos	1968	11 750	I	Chihuahua
Santa María	El Tintero	1950	130 000	I	Chihuahua
Texcoco	Bordo Texcoco	1974	1 900	I	Chihuahua
Texcoco	Texcoco	1974	2 150	I	Chihuahua
	Total - Hydrographic system :		233 160		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Symbols used in ""Purpose" column:
I: Irrigation.

Table 1.3

PAPER AND PULP INDUSTRIES IN THE NORTHERN ENDORHEIC HYDROGRAPHIC SYSTEM

River	Name of industry	Output (tons/year)		Locality	Administrative division
		Pulp	Paper		
(Mexico)					
Santa Isabel	Celulosa de Chihuahua	1 200	-	Anahuac	Chihuahua
		1 200	-		
	Total - Hydrographic system:	1 200	-		

Source: ECLAC, on the basis of official data.

Table 1.4

NORTHERN ENDORHEIC HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Mexico) a/							
Chihuahua	140 840	699 272	5.0	919 139	6.5	1 143 122	8.1
Total - Hydrographic system:	140 840	699 272	5.0	919 139	6.5	1 143 122	8.1

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras 1974. Situación demográfica: estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

a/ Dates of censuses: 08-06-60, 28-01-70, 04-06-80.

II. RIO BRAVO BASIN

A. GEOGRAPHY OF THE AREA

1. Introduction

The Río Bravo (Río Grande) basin 1/ is the watershed for the surface flows found in an area of approximately 214 096 km^2 in north-eastern Mexico. To the north it is bounded by the State of Texas in the United States; to the west, by the Northern Endorheic, California (Sierra Madre Occidental) and Southern Endorheic (Llano de los Gigantes, Llano de Guaje, Sierra Madre Oriental) hydrographic systems; and to the south, by the Gulf of Mexico hydrographic system, which is separated from the Río Bravo system by the spurs of the Sierra Madre Oriental that extend to the coast. The major watercourses are the Conchos River in the plains and the Salado River in the reservoir zone. The basin stretches between 24°30'and 31°30' north latitude and between 97° and 107°30' west longitude, and thus covers part of the states of Chihuahua, Coahuila, Nuevo León and Tamaulipas (see map 2.1).

2. Climate

a) Climate types (Köppen classification): The Río Bravo basin is located in the arid zone of northern Mexico where the dry climates (type B) of the inland plateaus and mountain ranges predominate. Moving in a NW-SE direction from Ciudad Juárez towards the Gulf coast, the climate changes from a dry desert (BW) to a dry steppe (BS) climate in the whole of the northern part of the states of Coahuila and Nuevo León up to 26° north latitude, and then to a temperate climate with scanty rainfall throughout the year (Cx).

The upper Conchos River basin, along the eastern slope of the Sierra Madre Occidental, has a dry steppe climate (BS), as does a small zone parallel to the Río Bravo in the lower Conchos River

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1/ For the purpose of this study, only the right bank of the Río Bravo (Río Grande) is considered, since this river forms the northern boundary of the study area.

basin. A type Cx climate is also found in a limited portion of the upper Salado River basin (see map 2.2).

b) Precipitation: In the Río Bravo basin, the rainfall is heaviest in the extreme west (eastern slope of the Sierra Madre Occidental, in the upper Conchos River basin) and in the coastal zone (extreme north of the State of Tamaulipas). The least rainfall occurs all along the right bank of the Río Bravo between the city of El Paso to the west and 102° west longitude to the east.

A total of four different rainfall zones, defined in terms of the origin and volume of precipitation, can be identified within the basin. The first zone encompasses the upper Conchos River basin, where the mean annual precipitation is around 800 mm. Rainfall is concentrated in the winter and is mainly of a convectional and orographic origin.

The second rainfall zone covers a narrow strip immediately following the area described above, as well as the entire coastal zone of the basin. This area has annual means of between 250 to 700 mm, and the rainfall is mainly produced by convectional and orographic phenomena in the Sierra Madre Occidental sector and by tropical waves and tropical cyclones in the coastal zone.

The third rainfall zone corresponds to a transitional area between the second zone and the most arid zone, which is located in the central part of the basin (see map 2.3). This is a semi-arid zone having between 250 and 700 mm of rainfall, most of which is accounted for by convection and by orographic effects. During the winter, the jet stream and frontal systems are the chief sources of rainfall. In the summer, the rainfall is heavier and is primarily due to the secondary effects of tropical cyclones or to tropical waves which penetrate inland from the Gulf.

The fourth rainfall zone is the most arid one. Most of this area has less than 250 mm of rainfall annually. The rainfall is produced by the same phenomena as in the second zone, but in the fourth zone a high-pressure area inhibits precipitation (see map 2.3 and table 2.1).

c) Temperature: The mean annual temperatures in the Río Bravo basin are progressively lower as one moves north (due to the latitude) and as one moves towards the west (due to the altitude). The entire basin is within the subtropics, where seasonal temperature variations are typically greater. As is also true in the case of mean annual temperatures, the temperature differences between the winter and summer months become greater as the altitude of the land increases to the north and towards the interior. In the area between 24° and 28° north latitude, the range of mean monthly temperatures is from 12°C to 18.5°C; between 28° and 31° north latitude, the range is from 18.5° to 22°C (see table 2.1).

3. Geomorphology and soils

The Río Bravo basin contains two clearly differentiated major physiographic units: the high plateau or mesetas, and the coastal plains along the Gulf of Mexico. The former is a large uplifted plain made up of small sections of recent volcanic rock and of Pleistocene and Holocene sedimentary rock produced by the denudation of the Sierra Madre Occidental. This high plateau, which covers the whole of the western portion of the basin up to about 101° west longitude, does not, since it is an aseismic zone, exhibit any tectonic action. Unlike the plateaus composed of fill which surround the basin, where the rivers drain into inland lakes, the plateaus within the boundaries of the Río Bravo basin and its tributary, the Conchos River, are the product of denudation due to the exorheic character of the basin. This denudation of the ancient sedimentary rock which makes up the mesetas is, however, mitigated by the dry climate since, because the area has such scant precipitation, there is little rainfall erosion.

The coastal plain is constituted almost entirely of recent sedimentary rock except for the inselbergs, which are made up of older sedimentary rock (Mesozoic) and have much the same characteristics as the inland plateau. The inselbergs are "left-overs" or "tokens" of a higher paleorelief and a wetter paleoclimate than those of today. The relief of this area ranges from somewhat slanted slope in the inland portion to a plain having a very gentle gradient in the extreme east.

A total of, at least, seven soil types are to be found within the basin, xerosols, yermosols, litosols, regosols, kastanozems, vertisols and gleysols (see Map 2.4).

The xerosols are arid zone soils with a high content of nutrient elements, but restricted in use to the existence of water for irrigation. In the subsoil, clay and calcic horizons make drainage difficult which means that, where irrigation is possible it must be practised with much care. These soils are found in the upper basin of the Conchos River, the main tributary of the Rio Bravo.

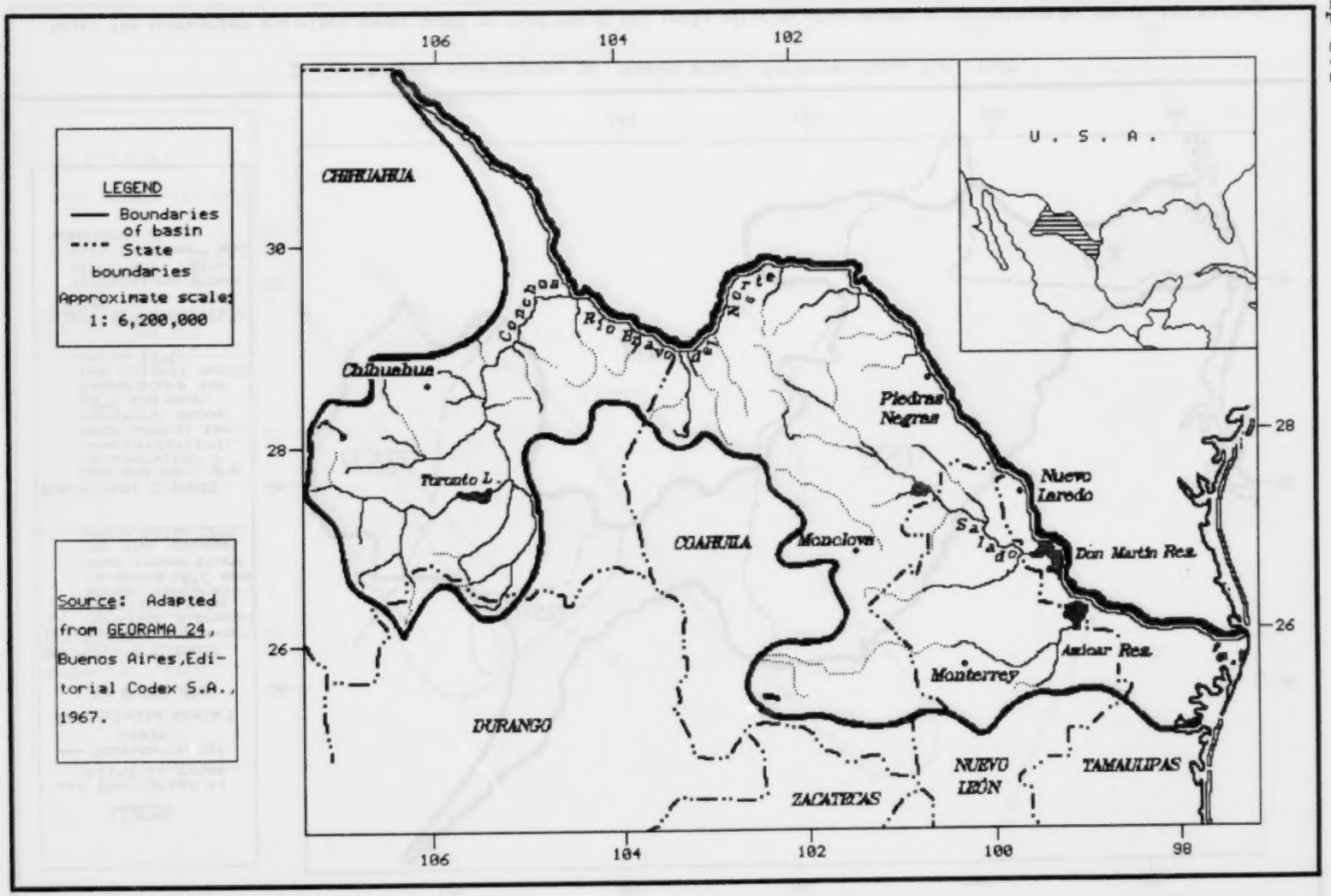
Yermosols are found in the middle section of the Conchos River basin. These soils are of little depth, porous and have a clay B horizon. When they are irrigated they are subject to salinization. Litosols a appear in a small area bewteen the yermosols and the regosols. They are formed from stony material and sands produced by wind erosion. The wind and the aridity of the zone mean that they are inert and unproductive.

Desert regosols, developed along the banks of the Rio Bravo and in the Conchos River basin, have a low water retention capacity. They form from accumulations of sands and windblown alluvium. They are unproductive unless irrigated.

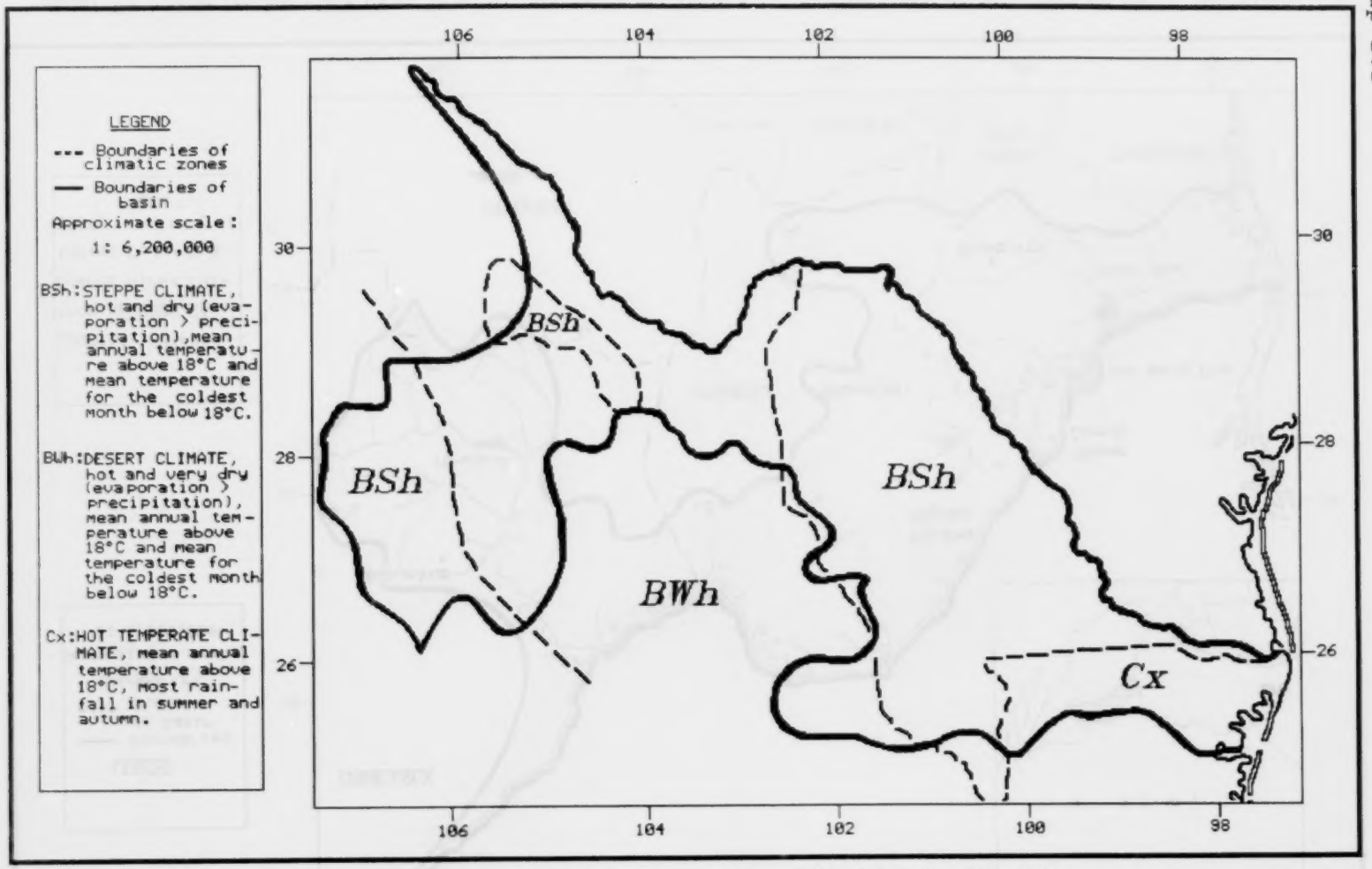
Kastanozems, found in the middle section of the Rio Bravo basin, when irrigated are very productive soils due to their high natural fertility and moderate organic content. They are also, however, prone to salinization with poorly managed irrigation.

The vertisols are clay soils of high fertility which can be used with good irrigation management. Irrigation permits the maintainance of humidity preventing hardening due to aridity.

The gleysols, at the river mouth, are difficult to exploit due to the lack of drainange. They tend to suffer from problems of consolidation, contraction, compaction and loss of sodium salts.

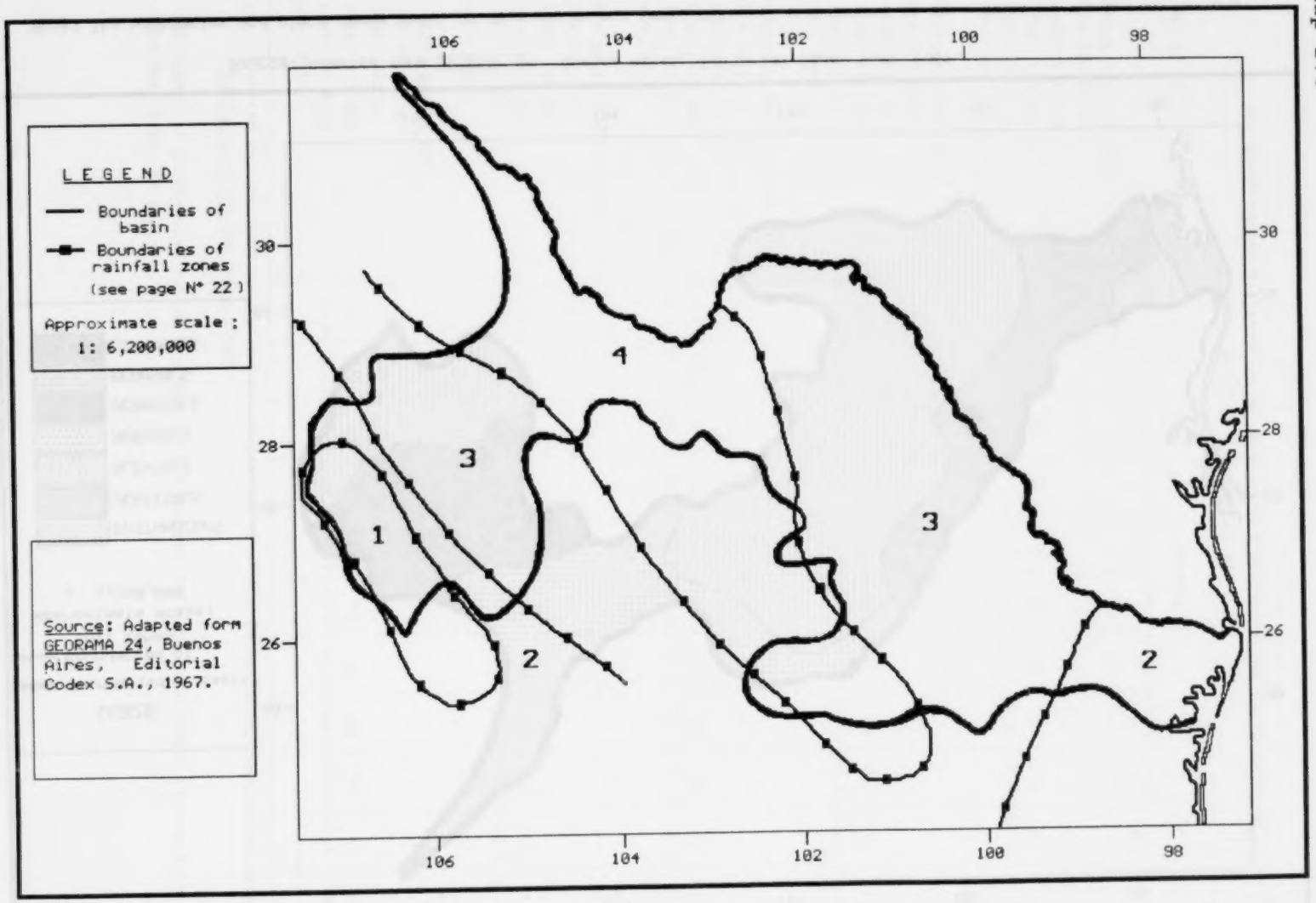


Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.


LEGEND
--- Boundaries of climatic zones
— Boundaries of basin
Approximate scale:
1: 6,200,000
BSh: STEPPE CLIMATE, hot and dry (evaporation > precipitation), mean annual temperature above 18°C and mean temperature for the coldest month below 18°C.
BWh: DESERT CLIMATE, hot and very dry (evaporation > precipitation), mean annual temperature above 18°C and mean temperature for the coldest month below 18°C.
Cx: HOT TEMPERATE CLIMATE, mean annual temperature above 18°C, most rainfall in summer and autumn.
106
104
102
100
98
30
28
26
BSh
BSh
BSh
BWh
Cx

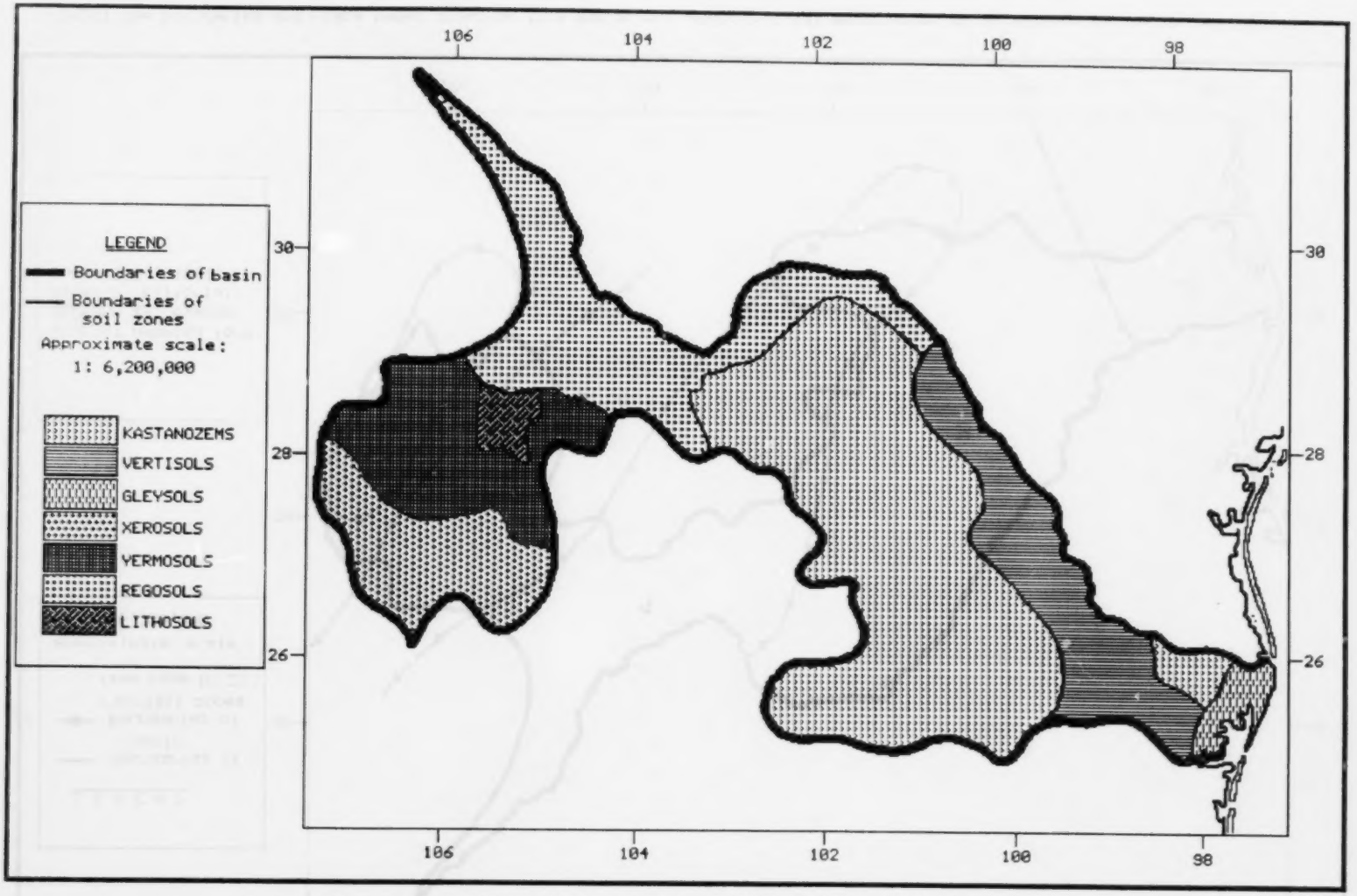
Source: Adapted form GEORAMA 24 , Buenos Aires, Editorial Codex S.A., 1967.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.



Map 2.3

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.



Map 2.4

Source: Adapted form GEORAMA 24 , Buenos Aires, Editorial Codex S.A., 1967.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 2.1

RIO BRAVO BASIN: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 2.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
CHIHUAHUA, Mexico (23)												
28°38'N-106°05'W												
Altitude: 1 423 m												
mmp (map: 350 mm)	7	5	5	5	11	34	86	86	72	22	9	8
mmt (mat: 18.7°C)	9.8	12.2	15.5	20.0	24.1	27.1	25.6	24.9	22.6	18.9	13.8	10.1
Climate: BSh												
MONCLOVA, Mexico (23)												
26°53'N-101°25'W												
Altitude: 591 m												
mmp (map: 370 mm)	11	15	7	18	28	44	47	57	93	28	14	8
mmt (mat: 22.0°C)	13.0	14.8	18.9	24.4	27.1	29.1	29.5	29.2	26.1	22.1	16.6	13.4
Climate: BSh												
NUEVO LAREDO, Mexico (15)												
27°29'N-99°30'W												
Altitude: 140 m												
mmp (map: 407 mm)	24	24	21	26	64	41	29	20	78	28	27	26
mmt (mat: 24.6°C)	14.1	17.8	20.8	25.2	28.1	30.4	32.5	32.3	29.9	26.5	21.0	16.1
Climate: BSh												
PIEDRAS NEGRAS, Mexico (30)												
28°42'N-100°31'W												
Altitude: 220 m												
mmp (map: 531 mm)	22	26	17	48	83	54	48	49	81	67	17	19
mmt (mat: 21.7°C)	11.1	14.2	18.2	22.8	26.4	29.6	30.7	30.3	27.2	22.2	15.6	11.6
Climate: BSh												
MONTERREY, Mexico (23)												
25°40'N-100°18'W												
Altitude: 538 m												
mmp (map: 611 mm)	15	18	16	27	39	70	66	80	150	85	26	19
mmt (mat: 22.3°C)	14.9	16.9	20.0	24.0	26.0	27.7	28.4	28.2	25.8	22.3	18.1	15.7
Climate: BSh												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

Table 2.1 (concl.)

b/ The abbreviations used in this column are:
BSh: dry and hot steppe climate
map: mean annual precipitation
mmp: mean monthly precipitation
mat: mean annual temperature
mmt: mean monthly temperature

c/ The cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millemetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrado degrees (°C).

B. STATISTICAL DATA CONCERNING WATER USE

Table 2.2

DAMS IN THE RIO BRAVO BASIN

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3)	Purpose a/	Administrative division
(Mexico)					
Arroyo Blancas	Santa Rita	1970	1 800	I	Nuevo León
Arroyo Los Bueyes	El Cinco	1969	2 500	I	Nuevo León
Bravo	Internacional Falcón	1953	2 960 000	I,H,C	Tamaulipas
Bravo	Internacional La Amistad	1968	4 379 000	I,H	Coahuila
Camargo	La Boquilla	1916	3 990 800	I,H	Chihuahua
Chuvíscar	Chuvíscar	1910	2 100	S	Chihuahua
Chuvíscar	Chihuahua	1960	32 300	C,S	Chihuahua
Conchos	Colina	1927	23 700	...	Chihuahua
Conchos	La Rosetilla	1931	19 400	H	Chihuahua
Conchos	Luis L.León	1968	850 000	I,C	Chihuahua
Conchos	Toribio Ortega	1973	9 580	I	Chihuahua
Corralejo	El Chamal	1969	7 500	I	Tamaulipas
Cradón y Venado	El Porvenir	1961	750	I	Nuevo León
De Allende	Talamantes	1902	31 000	I	Chihuahua
De Vázquez	Agualeguas	1966	10 000	I	Nuevo León
Der.Aguanaval	Tanque Genty	1981	13 000	I	Coahuila
Derramadero	La Navaja	1973	1 450	I	Tamaulipas
El Carmen	Las Lajas	1964	91 000	I	Chihuahua
El Carmen	El Carmen	1968	1 200	I	Nuevo León
El Chiflón	El Entronque	1972	5 600	I	Coahuila
El Chocolate	La Estrella	1969	3 000	I	Nuevo León
El Guardado	La Escondida	1970	10 000	I	Tamaulipas
El Rejón	El Rejón	1965	7 800	C,S	Chihuahua
El Saucito	El Saucito	1963	1 000	I	Chihuahua
El Sauz	San Lorenzo	1982	197 000	R	Tamaulipas
El Tolillo	La Parrita	1959	3 600	I	Coahuila
El Tulillo	Hipólito	1905	10 000	I	Coahuila
Flechadores	La Loba	1969	21 000	I	Tamaulipas
Florido	El Porrazo	1963	2 000	I	Chihuahua
Guayalejo	Animas	1978	665 000	I	Tamaulipas
Idolos	Sombreretillo	1970	6 000	I	Nuevo León
La Boca	Las Aguilas	1979	3 000	I	Coahuila
La Laja	Loma Larga	1968	2 000	I	Nuevo León
La Lajilla	La Lajilla	1977	5 000	I	Tamaulipas
La Pita	Santa Rosa	1969	2 000	I	Nuevo León
Los Hoyos	Los Hoyos	1975	1 600	I	Nuevo León
Nacapa	Nacapa	1968	3 500	I	Coahuila
Nochebuena	Nochebuena	1978	40 000	I	Coahuila
Pablillo	Cerro Prieto	1982	300 000	S,I	Nuevo León
Parral	Parral	1951	10 170	C,S	Chihuahua
Rancherías	Rancherías	1966	1 090	I	Nuevo León

Table 2.2 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3)	Purpose a/	Administrative division
S.Engracia y Corona	Santa Engracia	1947	4 260	I	Tamaulipas
Sacramento	San Marcos	1905	9 000	I	Chihuahua
Salado	Venustiano Carranza	1932	1 385 000	I,C	Coahuila
Salado y Salinas	Salinillas	1930	19 000	C	Nuevo León
San Antonio	La Lagunilla	1962	5 800	I	Coahuila
San Antonio	Bordo El Salto	1974	1 100	I	Chihuahua
San Diego	El Centenario	1936	15 000	I	Coahuila
San Juan	Marte R.Gómez	1946	1 241 100	I	Tamaulipas
San Juan	La Boca	1961	40 000	I,S	Nuevo León
San Juan	Pedro J.Méndez	1978	30 000	I	Tamaulipas
San Pedro	Francisco I.Madero	1949	425 000	I	Chihuahua
San Pedro	La Boca No. 1	1964	600	I	Tamaulipas
San Rafael	República Española	1972	75 000	I	Tamaulipas
Santa Isabel	Jacales	1963	4 500	I	Chihuahua
Seis de Enero	Cajas Coloradas	1975	1 300	I	Chihuahua
Soto La Marina	La Patria es Primero	1971	75 580	I	Tamaulipas
Soto La Marina	Vicente Guerrero	1971	3 900 000	I	Tamaulipas
Sta.Lucía	Magdaleno Aguilar	1959	500	I	Tamaulipas
Tranque Bravo	La Azufrosa	1980	5 000	I	Coahuila
Valsequillo	Torreoncillos	1958	6 000	I	Chihuahua
Valsequillo	Integración Latinoamericana	1975	23 000	I	Coahuila
Valsequillo	SELA (Sistema Económico Latinoamericano)	1975	8 800	I	Chihuahua
		Total - Basin :	21 002 980		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Symbols used in "Purpose" column:
- C: Flood control
- H: Hydroelectricity
- I: Irrigation
- R: Recreational purposes
- S: Water supply

Table 2.3

RIO BRAVO BASIN: HYDROELECTRIC PLANTS

River	Name of plant	Capacity (MW)	Administrative division	Locality
(Mexico)				
Bravo	Falcón	32.0	Tamaulipas	Guerrero
Conchos	La Boquilla	25.0	Chihuahua	San Fco de Concaos
	Total - Basin :	57.0		

Source: ECLAC, on the basis of official data.

Table 2.4

RIO BRAVO BASIN: THERMOELECTRIC PLANTS

River	Name of plant	Capacity (MW)	Administrative division	Locality
(Mexico)				
...	Venustiano Carranza	38.0	Coahuila	Nava
Chuvíscar	Chihuahua	76.0	Chihuahua	Chihuahua
Manantial Cabecera	Chavez	30.0	Coahuila	Francisco I Madero
Nazas	Emilio Portes Gil	75.0	Tamaulipas	Río Bravo
Pantano	Monterrey	393.0	Nuevo León	San Nicolás
Pesquería	La Leona	28.0	Nuevo León	Monterrey
Pesquería	San Jerónimo	105.0	Nuevo León	Monterrey
Pesquería	Tecnológico	30.0	Nuevo León	...
Pesquería	Universidad	28.0	Nuevo leon	Monterrey
San Pedro	Francisco Villa	66.0	Chihuahua	Delicias
	Total - Basin :	869.0		

Source: ECLAC, on the basis of official data.

Table 2.5

RIO BRAVO BASIN: OIL REFINERIES

River	Name of refiney	Barrels per day	Administrative division	Locality
(Mexico)				
Bravo	Reynosa	20 500	Tamaulipas	Reynosa
San Juan	Cadereyta	100 000	Nuevo León	Cadereyta
	Total - Basin:	120 500		

Source: ECLAC, on the basis of data compiled by the Latin American Energy Organization (OLADE), 1979.

Table 2.6

RIO BRAVO BASIN: IRON AND STEEEL INDUSTRIES

River	Name of industry	Output (tons)	Administrative division	Locality
(Mexico)				
Nadadores	Altos Hornos de Mexico (AHMSA)	3 300 000	Coahuila	Monclova
Pesquería	Fundidora de Monterrey	1 000 000	Nuevo León	Monterrey
Pesquería	Hojalata y Lámina HYLSA	555 000	Nuevo León	San Nicolás
	Total - Basin:	4 855 000		

Source: ECLAC, on the basis of data compiled by the Latin American Iron and Steel Institute (ILAFA), 1974.

Table 2.7

RIO BRAVO BASIN: PAPER AND PULP INDUSTRIES

River	Name of industry	Output (tons/year) Pulp	Paper	Locality	Administrative division
(Mexico)					
Bravo	Celanese Mexicana	6 000	-	Río Bravo	Tamaulipas
Chuvíscar	Papelera de Chihuahua	-	16 000	Chihuahua	Chihuahua
Pantano	Cía. Papelera Maldonado	3 500	35 000	San Nicolás	Nuevo León
Pantano	Productora de Papel	27 000	40 000	San Nicolás de las Garzas	Nuevo León
Pesquería	Empaques de Cartón Titán	20 400	55 000	Monterrey	Nuevo León
Pesquería	Fábrica de Papel Monterrey	-	6 900	Monterrey	Nuevo León
	Total - Basin :	56 900	152 900		

Source: ECLAC, on the basis of official data.

Table 2.8

RIO BRAVO BASIN: NON-FERROUS METALS INDUSTRIES

River	Type of industry	Name of industry	Output (tons)	Locality	Administrative division
(Mexico)					
Chuvíscar	Fundición y refinería de plomo	Ind. Minera México S.A.	136 800	Chihuahua	Chihuahua
Pesquería	Fundición de zinc	Zincamex S.A.	30 000	Saltillo	Coahuila
Sabinas	Fundición de zinc	Industrial Minera México S.A.	61 000	Rosita	Coahuila
		Total - Basin :	227 800		

Source: American Bureau of Metal Statistics Inc. (ABMS), Non Ferrous Metal Data 1983, New Jersey, Port City Press, Inc., 1984.

Table 2.9

RIO BRAVO BASIN: CITIES HAVING POPULATIONS OF OVER 100 000 AS OF 1980

River	City	Population 1950	1960	1970	1980	Administrative division
(México)						
Bravo	Ciudad Juárez	122 726	276 995	436 054	625 040	Chihuahua
Bravo	Matamoros	45 737	143 043	182 887	193 305	Tamaulipas
Bravo	Nuevo Laredo	57 669	96 043	150 922	223 606	Tamaulipas
Bravo	Reynosa	34 076	134 869	143 514	231 082	Tamaulipas
Chuvíscar	Chihuahua	86 961	186 089	363 850	385 953	Chihuahua
Pesquería	Monterrey	333 422	601 085	830 336	2 018 625	Nuevo León
Pesquería	Saltillo	69 869	127 772	191 879	258 492	Coahuila

Source: James W. Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLAC Latin American Center Publications, University of California, 1981, and ECLAC, on the basis of official data.

Table 2.10

RIO BRAVO BASIN: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Mexico) a/							
Chihuahua	86 480	429 378	5.0	564 384	6.5	701 917	8.1
Coahuila	83 364	499 254	6.0	613 226	7.4	856 496	10.3
Nuevo León	32 278	539 424	16.7	847 345	26.3	1 265 522	39.2
Tamaulipas	11 974	153 627	12.8	218 529	18.2	288 673	24.1
Total - Basin :	214 096	1 621 683	7.8	2 243 483	10.8	3 112 607	14.8

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras, 1974. Situación demográfica: estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

a/ Dates of censuses: 08-06-60, 28-01-70, 04-06-80.

III. CALIFORNIA HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The California hydrographic system encompasses the north-eastern part of Mexico and covers an area of approximately 471 473 km^2. It includes the entire Baja California peninsula, the states of Sonora and Sinaloa and part of the states of Chihuahua, Durango and Nayarit. To the north, its boundary coincides with the United States border; to the east, its boundary is the Sierra Madre Occidental; to the south, the Santiago River; and to the west, the Pacific Ocean. Surface flows are generally perpendicular to the mountain chain forming the eastern boundary of the system (i.e., they run NE-SW) and are short in length. The Yaqui and San Miguel rivers are exceptions to the above, in that they are longer and flow in a north-south direction due to the presence of a high plateau of an altitude of nearly 3 000 metres above sea level in the northern portion of the hydrographic system. The entire hydrographic system is within the subtropical zone between 22° and 32°30' north latitude and between 105° and 117° west longitude (see map 3.1).

2. Climate

a) Climate types (Köppen classification): The aridity of the climate in the California hydrographic system increases from east to west, i.e., as one moves away from the Sierra Madre Occidental towards the coast. An arid or dry climate (Bw) predominates in the Baja California peninsula and the State of Sonora, except in the region of the Juárez and San Pedro Mártir mountains to the north of the peninsula, where there is a temperate rainy climate, with the rainfall occurring during the winter (Cs). Towards the inland portion of the hydrographic system the climate is wetter and more temperate (type C), and towards the south (the coastal strip of the State of Sinaloa), there is a rainy tropical climate, with rainfall in summer (Aw). The latter type of climate is also found in the San Lázaro mountains in the Baja California peninsula. The greater aridity characterizing the area south of 30° north latitude in the

Baja California peninsula is due to the influence of the cold California ocean current (se map 3.2).

b) Precipitation: Six of the eight rainfall zones that have been identified within Mexican territory are present in the California hydrographic system. Precipitation ranges from less than 250 mm annually in the north-western portion of the system to over 1 000 mm annually in the Sierra Madre Occidental in the State of Durango.

The first rainfall zone is in the north-western sector of the Baja California peninsula between the United States border and approximately 30° north latitude. The rainfall in this zone occurs during the winter months and is due to incursions of cooler sea air coming down from the polar region, the passage of frontal systems and, occasionally, the effects of descending cold air. The greatest amount of precipitation in this zone, around 300 mm annually, occurs in the upper reaches of the Juárez and San Pedro Mártir mountains.

The second rainfall zone corresponds to the central portion of the Baja California peninsula and the strip of land to the north of the Gulf of California bordering on the United States. This zone is extremely dry (less than 250 mm annually) due to the inversion of the trade winds, which block vertical cloud build-up. During the winter, subtropical systems, frontal systems or descending cold air occasionally produce some precipitation. In the summer, weakened tropical cyclones sometimes bring rain to the central portion of the peninsula.

The third zone covers the coast of the State of Sonora from the United States border up to 28° north latitude and the part of the Baja California peninsula to the east of 112° west longitude. The scant rainfall occurring in this zone, caused by orographic and convectional phenomena, is occasionally augmented by frontal systems in the winter and, in the summer, by lines of confluence, tropical waves or the effects of tropical cyclones in the southern part of the Baja California peninsula. Mean annual precipitation does not exceed 250 mm.

The fourth rainfall zone corresponds to the plains and the coastal area of the State of Sonora and the northern coastal section of the State of Sinaloa. This is a semi-arid region in which precipitation ranges from 250 mm in the far western portion of the zone to 700 mm annually in the extreme east. The rainfall is mainly caused by convection and orographic phenomena.

The fifth rainfall zone takes in the Sierra Madre Occidental in the inland portion of the hydrographic system and the southern coast of the State of Sinaloa. The amount of precipitation in this area increases from west to east and ranges from 250 up to 2 000 mm at some of the higher altitudes in the Sierra Madre Occidental.

The precipitation is produced chiefly by convectional and orographic phenomena.

The sixth rainfall zone covers a small area in the extreme south of the hydrographic system. The mean annual precipitation for this area is over 700 mm and reaches up to 2 000 mm in the mountains. The rainfall is caused by the passage of fronts that are coupled with northerly winds during the winter and by the effects of tropical cyclones and waves during the summer (see map 3.3 and table 3.1).

c) Temperature: The main factors determining the temperatures in the California hydrographic system are the latitude of those areas under 1 000 metres above sea level, the altitude of the terrain in those areas over 1 000 metres above sea level, and the marine influence on the windward side of the system. Mean annual temperatures decrease as one moves out from the centre of the system (the coastal zone of the Gulf of California) towards its periphery. They also diminish towards the east, as a result of the increase in altitude, and towards the west (i.e., towards the Pacific coast of the Baja California peninsula), because of ocean influence. Mean annual temperatures vary between 20° and 25°C along the Gulf coast and gradually diminish to less than 10°C at altitudes above 2 000 m in the Sierra Madre Occidental. The north-western portion of the Baja California peninsula is relatively cooler owing to its latitude and its proximity to the ocean. Mean annual temperatures in this area range from 6°C in the Juárez and San Pedro Mártir mountains up to 18°C in some inland sectors between these mountains and the Pacific coast.

Seasonal temperature variations become progressively greater from south to north and towards the east as the degree of continentality increases. Due to the existence of a major body of water (the Gulf of California), seasonal differences are less marked in the coastal zones (see table 3.1).

3. Geomorphology and soils

The California hydrographic system encompasses three major physiographic units: the Baja California peninsula; the plains of the states of Sonora, Sinaloa and Nayarit and the Gulf of California; and the Sierra Madre Occidental.

The Baja California peninsula is the continuation of a series of anticlinoria running along the entire Pacific coast of North America. In all these anticlines, the mountains contain a large quantity of azoic igneous rocks, as well as intrusive rock in the form of batholiths and, in some cases, sedimentary rock from the Paleozoic. A large section of the mountains in the central region are covered by volcanic rock (tuff). This mountain system is joined by a small plain of terraces of marine origin on the western coast,

but there are no such plains on the eastern coast. The climate of this area is now very dry, and most of the erosion that occurs is therefore caused by wind.

The plains and the Gulf depression are the continuation of a series of inter-montane plateaus in the western part of the American continent which decrease in altitude as one moves southwards. In this syncline the depressions have been transformed into tablelands which were originally composed of fill that was in some cases covered by lava flows, but which have since become denuded. The material carried down from the Sierra Madre Occidental by the process of denudation has been deposited in the lower-lying areas. Because of the predominantly dry climate, wind erosion is a particularly important factor of denudation as regards the material deposited in past ages.

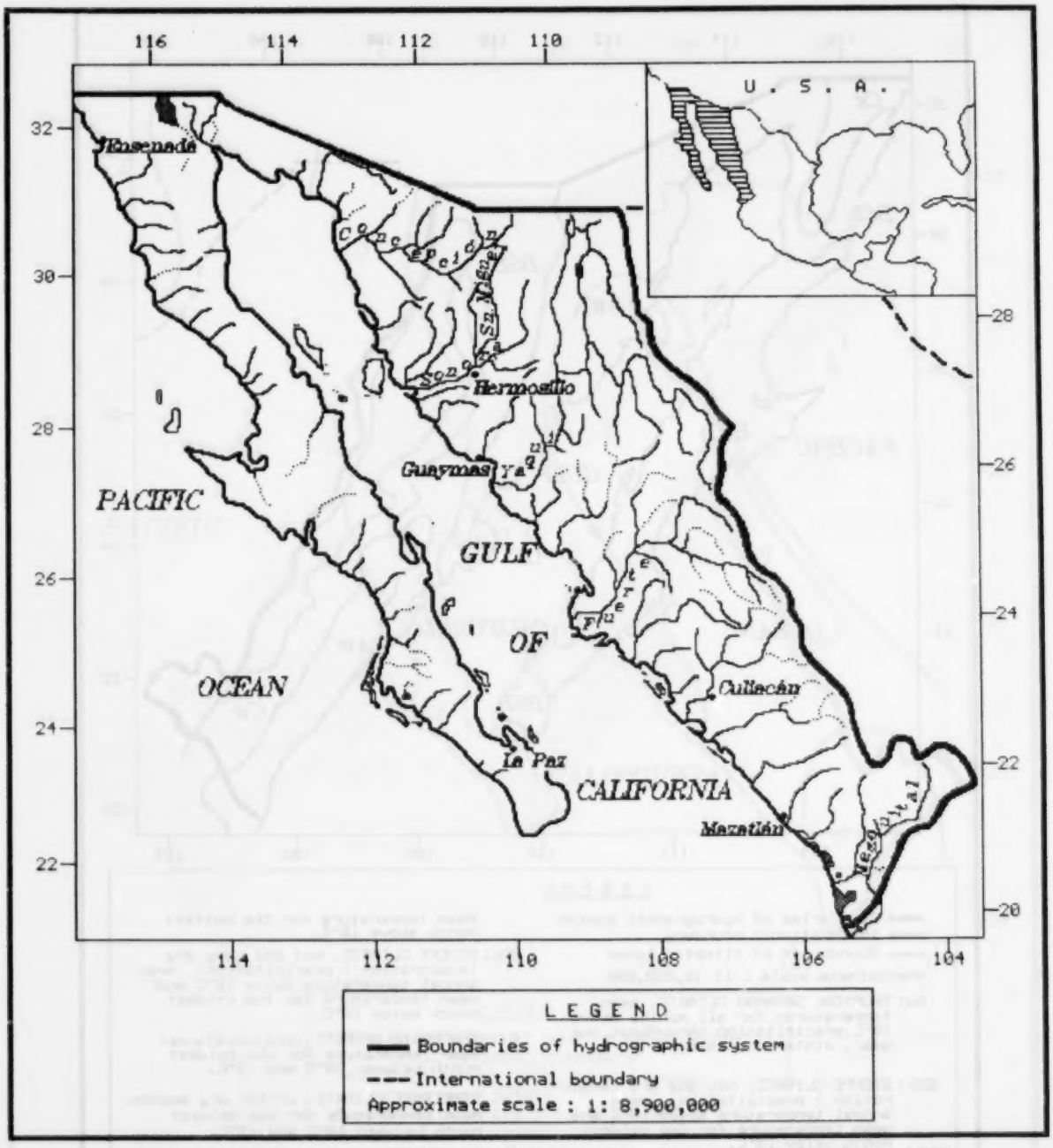
The Sierra Madre Occidental lies in the eastern part of the hydrographic system and is made up almost entirely of andesitic rock, except for some recent volcanic rock in a few areas. This physiographic unit is a continuation of the Rocky Mountains in the United States and reaches altitudes of up to 3 000 metres above sea level. This part of the mountain chain is not actively tectonic, since it does not exhibit any seismic or volcanic activity. The various soil zones occur in bands running in an approximately NW-SE direction and correspond to the prevailing climates.

Arid soils, with a low water retention capacity, with salinization problems and with low to medium inherent natural fertility, predominate within the system (see map 3.4). The poorest soils are the litosols, next the regosols, yermosols and xerosols in increasing suitability for agriculture. Their productivity is limited with careful irrigation due to their aridity and the existence of clay and calcic horizons in the subsoil.

The kastanozems surround the most desertic xerosols and yermosols which are found on the mountain slopes. They are mainly used for extensive grazing. In areas of less broken relief and with adequate irrigation, the kastanozems are highly productive as they show a high level of natural fertility and contain moderate amounts of organic material. Just like the most arid soils, however, they suffer from salinization with excessive irrigation.

Luvisols are found in a small area in the extreme northwest of the system and in the western Sierra Madre to the south. These soils are the most fertile of the region, but require irrigation and application of fertizers to obtain good productivity in almost all crops.

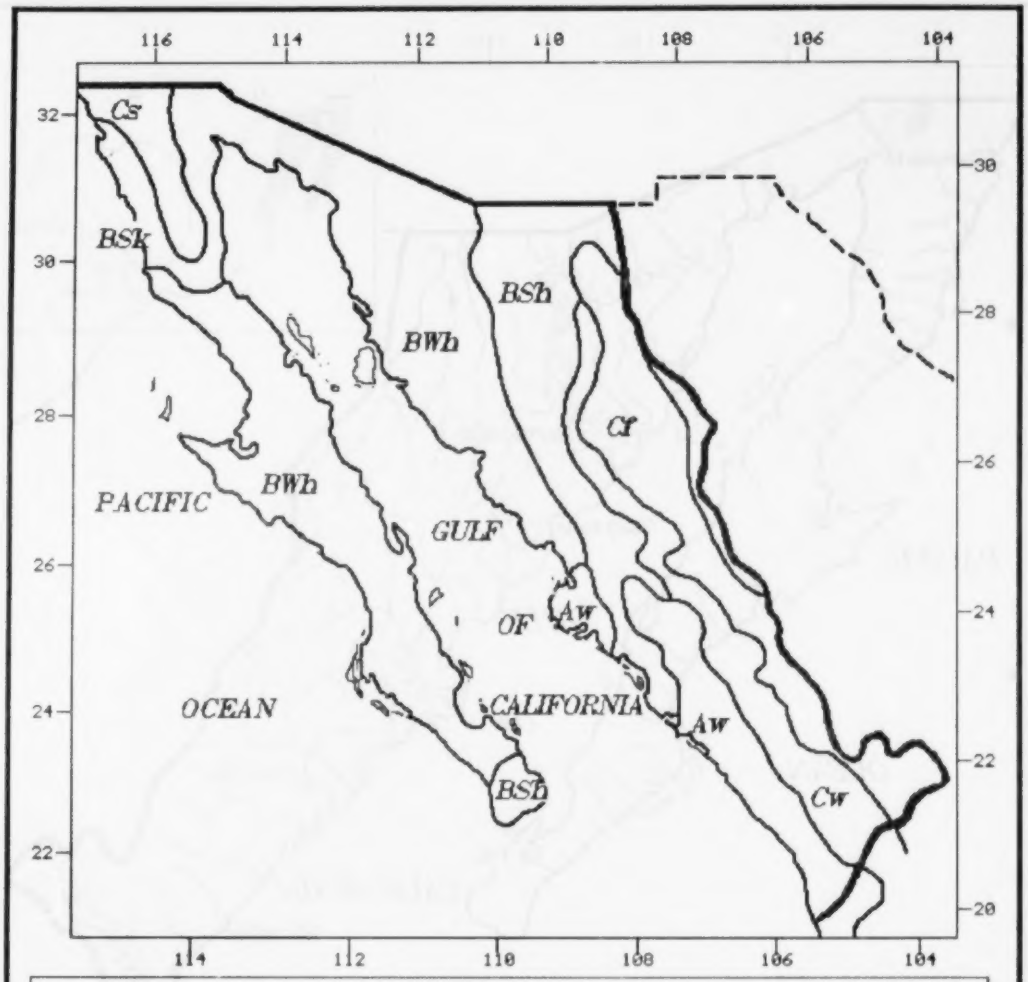
Map 3.1



Source: Adapted from GEORAMA 24, Buenos Aires, Editorial Codex S.A., 1967.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 3.2



LEGEND

Boundaries of hydrographic system
International boundary
Boundaries of climatic zones

Approximate scale : 1: 10,000,000

Aw: TROPICAL SAVANNA CLIMATE, mean temperatures for all months above 18°C, precipitation throughout the year, winter dry season.

BSh: STEPPE CLIMATE, hot and dry (evaporation > precipitation), mean annual temperature above 18°C and mean temperature for the coldest month below 18°C.

BSk: STEPPE CLIMATE, cold and dry (evaporation > precipitation), mean annual temperature below 18°C and mean temperature for the hottest month above 18°C.

BWh: DESERT CLIMATE, hot and very dry (evaporation > precipitation), mean annual temperature above 18°C and mean temperature for the coldest month below 18°C.

Cf: TEMPERATE CLIMATE, continously wet mean temperature for the coldest month between 18°C and -3°C.

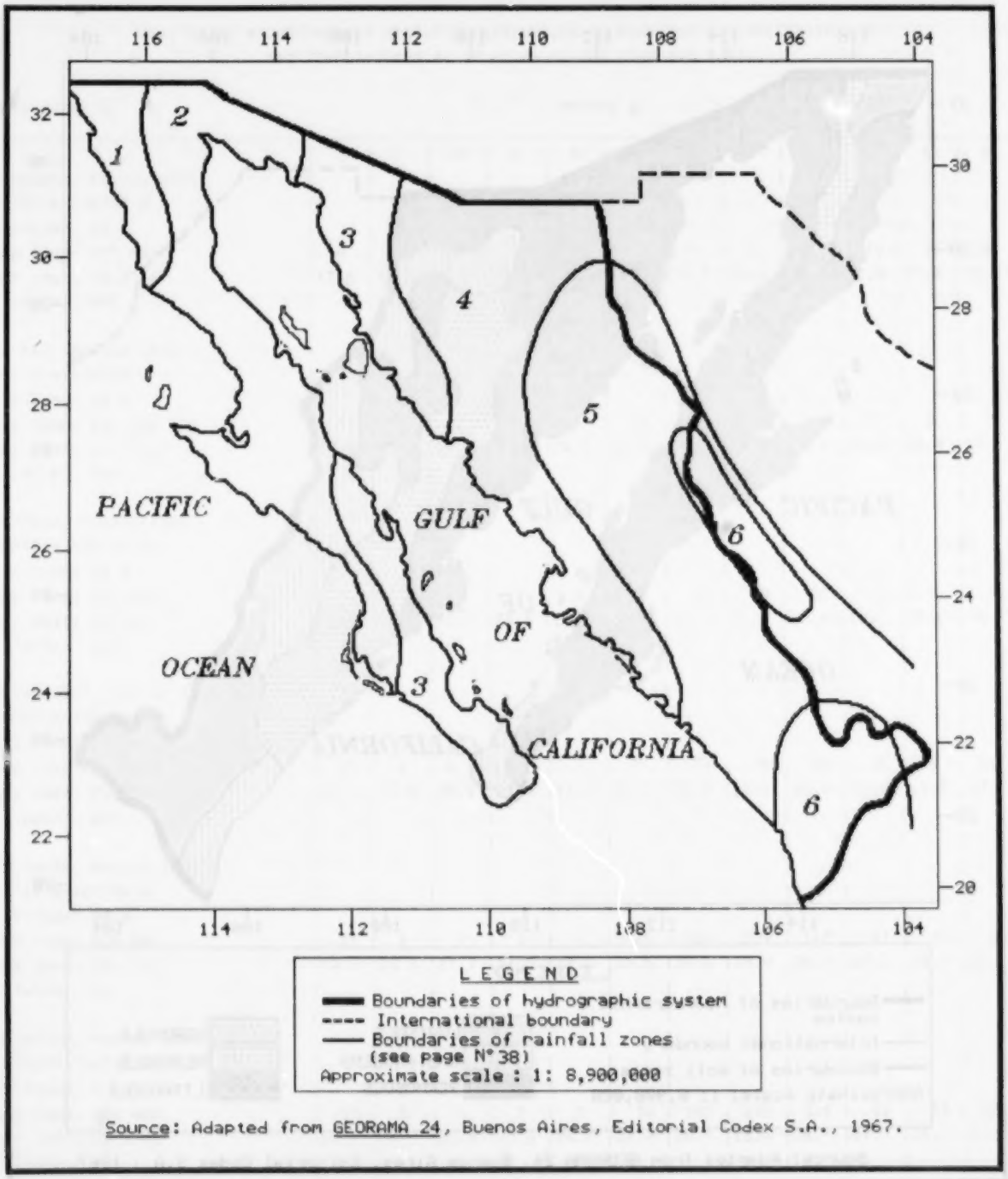
Cw: TEMPERATE CLIMATE, winter dry season, mean temperature for the coldest month between 18°C and -3°C.

Cs: TEMPERATE CLIMATE, summer dry season, mean temperature for the coldest month between 18°C and -3°C.

Source: Adapted from GEORAMA 24, Buenos Aires, Editorial Codex S.A., 1967.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

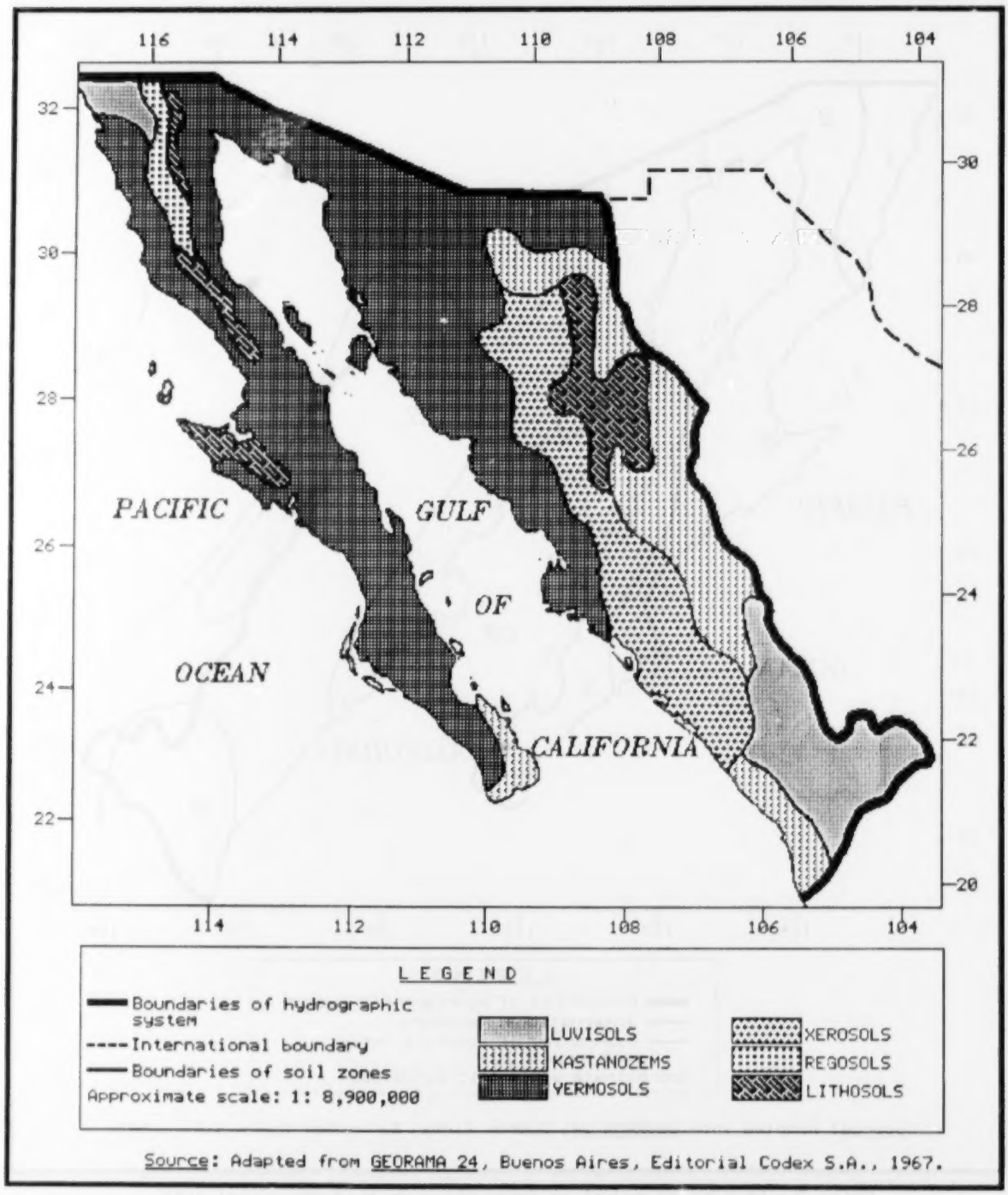
Map 3.3



Source: Adapted from GEORAMA 24, Buenos Aires, Editorial Codex S.A., 1967.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 3.4



Source: Adapted from GEORAMA 24, Buenos Aires, Editorial Codex S.A., 1967.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 3.1

CALIFORNIA HYDROGRAHPICH SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 3.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
ENSENADA, Mexico (30)												
31°51'N-116°38'W												
Altitude: 13 m												
mmp (map: 175 mm)	38	24	23	19	8	-	1	2	-	10	14	36
mmt (mat: 16.3°C)	12.6	13.1	13.6	15.1	16.3	17.7	19.7	20.6	20.0	17.8	15.6	13.3
Climate: BSk												
LA PAZ, Mexico (30)												
24°10'N-110°25'W												
Altitude: 10 m												
mmp (map: 224 mm)	11	5	2	1	4	22	19	46	56	37	6	15
mmt (mat: 23.9°C)	17.9	18.8	19.9	22.2	24.6	26.5	29.2	29.7	29.1	26.6	22.9	19.5
Climate: BWh												
GUAYMAS, Mexico (30)												
27°55'N-110°54'W												
Altitude: 44 m												
mmp (map: 224 mm)	27	7	6	1	3	2	43	69	28	15	9	14
mmt (mat: 25°C)	18.3	19.2	20.7	23.5	26.5	29.5	31.2	31.2	30.8	27.7	22.4	19.3
Climate: BWh												
HERMOSILLO, Mexico (30)												
29°04'N-110°58'W												
Altitude: 237 m												
mmp (map: 250 mm)	15	6	4	4	-	7	74	78	28	15	5	14
mmt (mat: 24.7°C)	16.4	17.8	19.9	23.9	27.2	31.3	32.3	31.4	30.9	26.9	20.9	17.1
Climate: BWh												
CULIACAN, Mexico (30)												
24°49'N-107°24'W												
Altitude: 84 m												
mmp (map: 700 mm)	25	9	7	3	-	25	164	229	147	41	11	39
mmt (mat: 25.1°C)	19.6	20.5	21.7	24.5	27.3	29.5	29.4	28.9	28.7	27.4	23.7	20.6
Climate: Aw												
MAZATLAN, Mexico (88)												
23°12'N-106°25'W												
Altitude: 3 m												
mmp (map: 776 mm)	18	8	5	1	1	34	163	215	225	65	19	22
mmt (mat: 24.3°C)	20.1	20.0	20.3	22.2	24.7	27.2	28.1	28.4	28.1	27.1	24.1	21.5
Climate: Aw												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

Table 3.1 (concl.)

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

b/ The abbreviations used in this column are:
Aw: tropical savanna climate, dry season in winter
BSk: cold and dry steppe climate
BWh: hot and very dry desert climate
map: mean annual precipitation
mmp: mean monthly precipitation
mat: mean annual temperature
mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication information was not available concerning oil refineries, steel industries and paper and pulp industries in this hydrographic system.

Table 3.2

DAMS IN THE CALIFORNIA HYDROGRAPHIC SYSTEM

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
Alamos	Josefa Ortíz de Domínguez	1967	485 000	I,C	Sinaloa
Altar	Cuauhtemoc	1950	45 000	I	Sonora
Babasac	Comaquito	1977	31 200	I	Sonora
Bavispe	La Angostura	1942	983 000	I	Sonora
Carrizo	Carrizo	1981	43 564	S	Baja California
Divisaderos	Divisaderos	1979	4 100	I	Sonora
El Horno	El Horno	1956	800	I	Sonora
El Plomo	El Plomo	1976	4 500	I	Sonora
El Yaqui	Plutarco Elías Calles	1964	3 030 000	H	Sonora
Elota	El Salto	1985	428 000	I,C	Sinaloa
Ensenada	Ensenada	1978	7	C,S	Baja California
Fuerte	Miguel Hidalgo	1956	3 290 000	I,C,H	Sinaloa
Humaya	Pdte.Adolfo López Mateos	1964	3 150 000	I,C	Sinaloa
Jecolúa	Jecolúa	1934	3 000	I	Sinaloa
Las Higueras	Las Higueras	1977	13 000	I	Sinaloa
Los Becos	Dique Los Becos	1969	31 300	I	Sinaloa
Los Horcones	Los Horcones	1980	14 000	I	Sinaloa
Matape	Punta de Agua	1970	26 000	I	Sonora
Matape	Gral.Ignacio L. Alatorre	1976	26 000	I	Sonora
Mayo	Adolfo Ruiz Cortines	1955	1 014 700	I,H,C	Sonora
Mocorito	Eustaquio Buelna	1972	343 800	I	Sinaloa
Motape	La Haciendita	1954	-	I	Sonora
Ocoroni	El Sabinal	1985	300 000	I,C	Sinaloa
Promontorio	El Veranito	1977	8 350	I	Sonora
Rebeico	Rebeico	1952	-	I	Sonora
Rebeico	El Rebeico	1980	1 200	...	Sonora
San Lorenzo	San Isidro	1897	2 890	I	San Luis Potosí
San Lorenzo	Jose López P.Pdte.	1981	2 850 000	I,H,C	Sinaloa
San Marcial	Ortíz	1958	30 000	I,C	Sonora
Santa María	Las Chepas	1968	7 000	I	Chihuahua
Sinaloa	Gustavo Díaz O.Pdte.	1982	1 800 000	I,H,C	Sinaloa
Sonora	Abelardo Rodríguez Lujan	1948	253 000	I,S	Sonora
Tamazula	Sanalona	1948	845 000	I,H	Sinaloa
Tijuana	Abelardo Rodríguez	1937	137 000	S	Baja California

Table 3.2 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
Tranque Magdalena	El Yeso	1971	4 000	I	Sonora
Villaverde	Villaverde	1962	1 850	I	Sonora
Yaqui	Alvaro Obregón (Oviachic)	1952	3 237 000	I,H,C	Sonora
	Total - Hydrographic system :		22 444 261		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Dams for which no reservoir capacity is given are lateral dams.
b/ Symbols used in "Purpose" column:
C: Flood control
H: Hydroelectricity
I: Irrigation
S: Water supply

Table 3.3

CALIFORNIA HYDROGRAPHIC SYSTEM: HYDROELECTRIC PLANTS

River	Name of plant	Capacity (MW)	Administrative division	Locality
(Mexico)				
Fuerte	El Fuerte	59.0	Sinaloa	El Fuerte
Humaya	Adolfo López Mateo	90.0	Sinaloa	Villa Adolfo López
Yaqui	Plutarco Elías	135.0	Sonora	Soyapa
	Total - Hydrographic system :	284.0		

Source: ECLAC, on the basis of official data.

Table 3.4

CALIFORNIA HYDROGRAPHIC SYSTEM: THERMOELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Mexico)				
...	Cerro Prieto	75.0	Baja California	Baja California
Fuerte	El Fuerte	59.0	Sinaloa	El Fuerte
Fuerte	Topolobampo	41.0	Sinaloa	Ahome
Gulf of California	Guaymas	98.0	Sonora	Guaymas
Gulf of California	Guaymas II	174.0	Sonora	Guaymas
Gulf of California	Rafael Puelma	40.0	Sinaloa	Mazatlán
Mezquital	Durango	35.0	Durango	Durango
Sonora	Hermosillo	32.0	Sonora	Hermosillo
Tijuana	Tijuana	307.0	Baja California	Tijuana
Yaqui	Ciudad Obregón	32.0	Sonora	Cajeme
	Total - Hydrographic system:	893.0		

Source: ECLAC, on the basis of official data.

Table 3.5

CALIFORNIA HYDROGRAPHIC SYSTEM: NON-FERROUS METALS INDUSTRIES

River or body of water	Type of industry	Name of industry	Output (tons)	Locality	Administrative division
(Mexico)					
Bocomuchi	Fundición de Cobre	Cía. Minera de Cananea S.A.	126 300	Cananea	Sonora
Gulf of California	Fundición de Cobre	Cía. Minera de Santa Rosalía SA	45 600	Santa Rosalía	Baja California
		Total - Hydrographic system :	171 900		

Source: American Bureau of Metal Statistics Inc. (ABMS), Non-Ferrous Metal Data 1983, New Jersey, Port City Press, Inc., 1984.

Table 3.6

CALIFORNIA HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

River or body of water	City	Population 1950	1960	1970	1980	Administrative division
(Mexico)						
Colorado	Mexicali	64 658	281 333	390 411	348 528	Baja California
Culiacán	Culiacán	48 963	208 982	358 812	324 292	Sinaloa
Mezquital	Durango	59 496	142 858	192 934	228 686	Durango
Pacific Ocean	Ensenada	18 140	64 934	113 320	139 317	Baja California
Pacific Ocean	Mazatlán	41 459	112 619	171 835	186 290	Sinaloa
Sonora	Hermosillo	43 516	118 051	206 663	319 257	Sonora
Tijuana	Tijuana	59 950	165 690	335 125	566 344	Baja California
Yaqui	Ciudad Obregón	-	220 011	466 531	181 733	Sonora

Source: James W.Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin American Center Publications, University of California, 1981, and ECLAC, on the basis of official figures.

Table 3.7

CALIFORNIA HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Mexico) a/							
Baja California	70 113	520 165	7.4	870 421	12.4	1 177 886	16.8
Baja California Sur	73 677	81 594	1.1	128 019	1.7	215 139	2.9
Chihuahua	19 767	98 143	5.0	129 002	6.5	160 438	8.1
Durango	53 842	342 376	6.4	422 644	7.8	532 044	9.9
Nayarit	11 048	155 972	14.1	217 612	19.7	290 448	26.3
Sinaloa	58 092	838 404	14.4	1 266 528	21.8	1 849 879	31.8
Sonora	84 934	783 378	4.2	1 098 720	5.9	1 513 731	8.2
Total - Hydrographic system	: 471 473	2 820 032	5.9	4 132 946	8.3	5 739 565	11.1

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras, 1974. Situación demográfica: estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

a/ Dates of censuses: 08-06-60, 28-01-70, 04-06-80.

IV. SOUTHERN ENDORHEIC HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The Southern Endorheic hydrographic system is located in central northern Mexico on the northern high plateau which is bounded on the east and west by the Sierra Madre Oriental and the Sierra Madre Occidental, respectively. This drainage system covers an area of approximately 236 637 km^2 and encompasses parts of the states of Coahuila, Durango, Nuevo León, San Luis Potosí and Zacatecas and a small portion of the State of Tamaulipas on the east. The geographic co-ordinates demarcating the system are 99° and 107° west longitude and 21°30' and 28°30' north latitude (see map 4.1).

2. Climate

a) Climate types (Köppen classification): Both temperate climates (type C) and dry climates (type B) are found in the Southern Endorheic Hydrographic system due to the differences in altitude between the central plateau and the mountain ranges to the east and west. The lower portion of the plateau in the southern part of the State of Coahuila has a hot desert climate (BWh), as do the northern and eastern parts of the states of Zacatecas and Durango, respectively. A cold steppe climate (BSk), which is slightly wetter and cooler than the above due to the altitude of the land, is found in the transversal mountain chains south-east of Coahuila, south-west of Nueva León, north of Durango and north of San Luis Potosí; this climatic zone partly surrounds the desert climate (which penetrates into this area from the north) in the form of a semicircle (cities of Saltillo and Durango). Finally, a temperate climate with rainfall in the summer (Cw) is found along the system's eastern (State of Nueva León), south-western (southern part of the State of Zacatecas) and western (State of Durango) boundaries. In the upper reaches of the Sierra Madre Occidental and Sierra Madre Oriental the climate is temperate with rainfall throughout the year (Cf) (see map 4.2).

b) Precipitation: The rainfall pattern in the southern endorheic hydrographic system is mainly determined by the complex

relief of the area. Generally speaking, the amount of precipitation grows greater as one moves from the northern central portion of the system towards its periphery (see map 4.3). Precipitation varies from less than 200 mm annually (city of Torreón: 177 mm) to more than 800 mm annually in the highest parts of the mountain ranges. Rainfall is concentrated in the summer months (June and July) but there is also some rainfall up to the beginning of autumn (August and September) (see table 4.1).

c) Temperature: Temperatures in the zone are a function of the altitude and of the rainfall pattern, which, since it increases with altitude, mitigates the temperature variations characteristic of mountainous areas. Annual isotherms range from 23°C in the lowest part of the central plateau to 15°C in the highest parts. Differences among mean monthly temperatures are from 10°C to 15°C depending upon local orographic characteristics and altitudes (see table 4.1).

3. Geomorphology and soils

In physiographic terms, the central plateau which crosses the Southern Endorheic hydrographic system from north-west to south-east is a continuation of the great plains of North America. This plateau is formed by fill made up of material carried down by erosion from the Sierra Madre Occidental and, to a small extent, from the Sierra Madre Oriental. The Sierra Madre Occidental is covered by volcanic matter and its mean altitude is between 2 100 and 2 200 metres but it reaches altitudes of up to 3 000 metres at some points. The headwaters of the system's major endorheic rivers, such as the Nazas, Cadena and Aguanaval, which define the smaller subsystems of the same names, are located in this range.

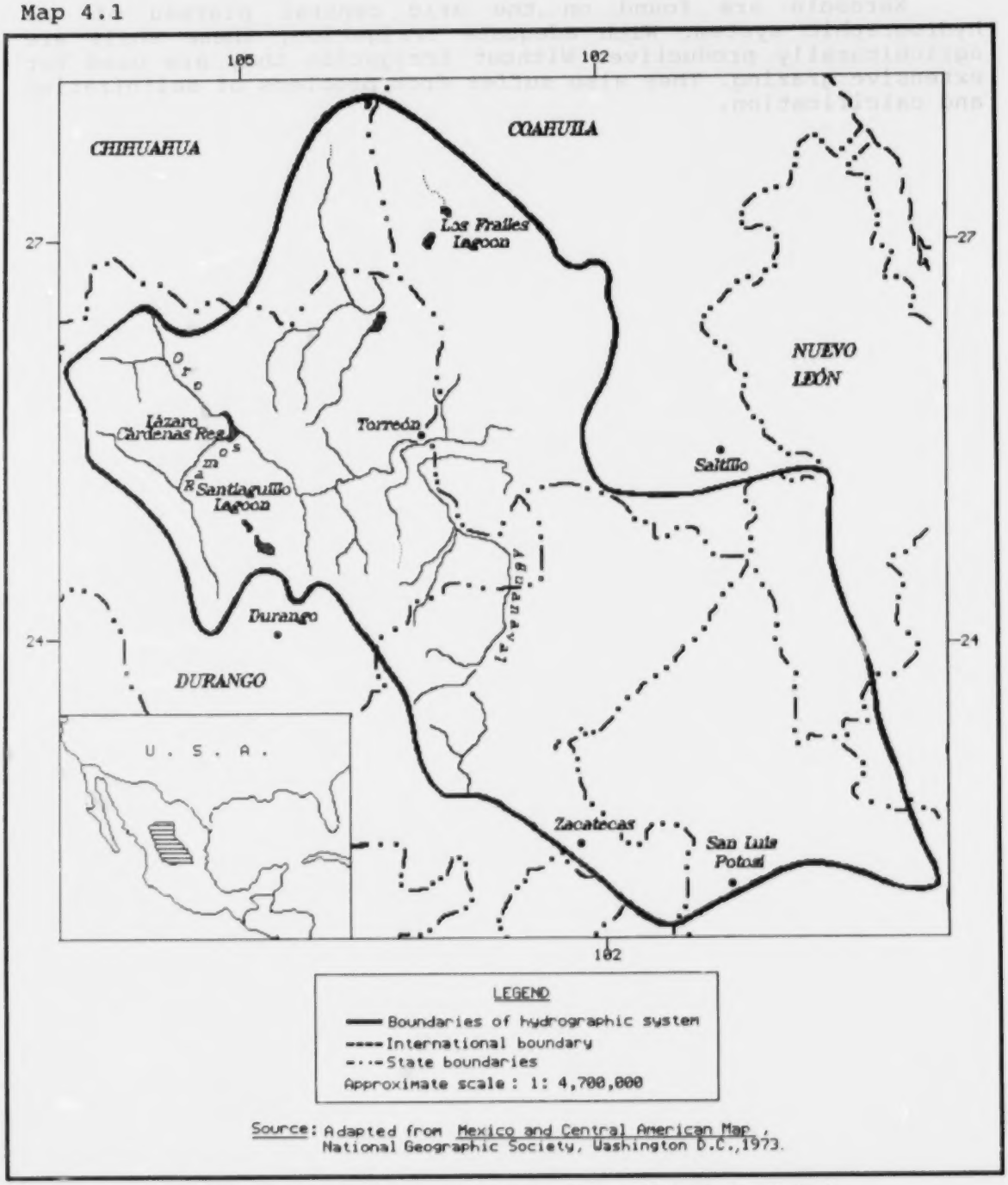
The predominant soil types in this region are associated with the different climates existing within the hydrographic system (see Map 4.4).

Litosols are found at the periphery of the hydrographic system associated with the steppe climate. These soils are thin and stony. They are only suitable for extensive or occasional grazing (after the rains) or for tree crops (coffee and citrus fruit) where soil fragmentation permits.

The kastanozems, with adequate irrigation, can be very productive in areas of little relief. They do present problems of salinization and calcification in the subsoil horizon. In more zones of more broken relief such soils are used for seasonal grazing.

Xerosols are found on the arid central plateau of the hydrographic system. With adequate irrigation, these soils are agriculturally productive. Without irrigation they are used for extensive grazing. They also suffer from problems of salinization and calcification.

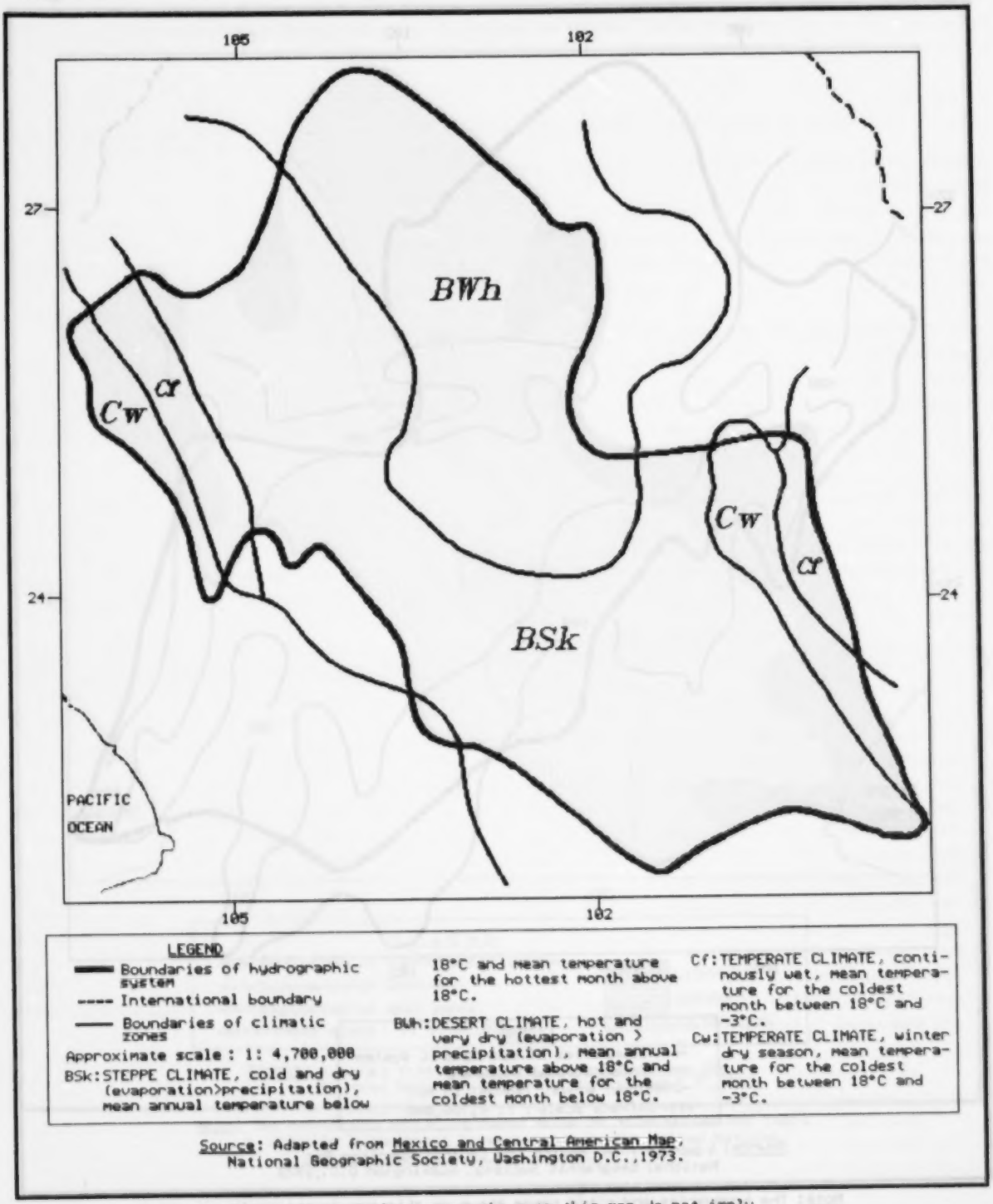
Map 4.1



Source: Adapted from Mexico and Central American Map, National Geographic Society, Washington D.C., 1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 4.2



LEGEND

Boundaries of hydrographic system

International boundary

Boundaries of climatic zones

Approximate scale : 1: 4,700,000

BSk: STEPPE CLIMATE, cold and dry (evaporation>precipitation), mean annual temperature below 18°C and mean temperature for the hottest month above 18°C.

BWh: DESERT CLIMATE, hot and very dry (evaporation > precipitation), mean annual temperature above 18°C and mean temperature for the coldest month below 18°C.

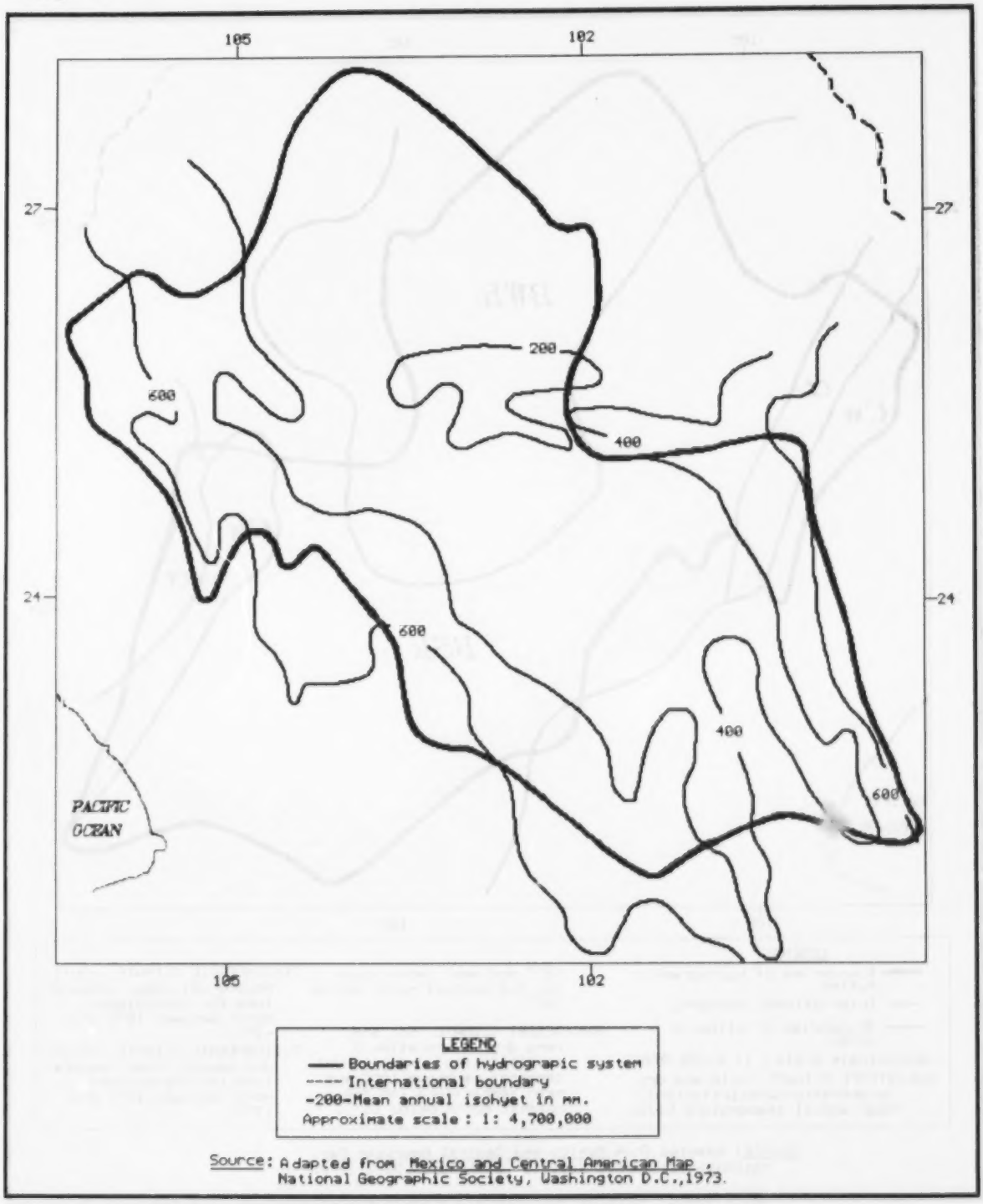
Cf: TEMPERATE CLIMATE, continously wet, mean temperature for the coldest month between 18°C and -3°C.

Cw: TEMPERATE CLIMATE, winter dry season, mean temperature for the coldest month between 18°C and -3°C.

Source: Adapted from Mexico and Central American Map, National Geographic Society, Washington D.C.,1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

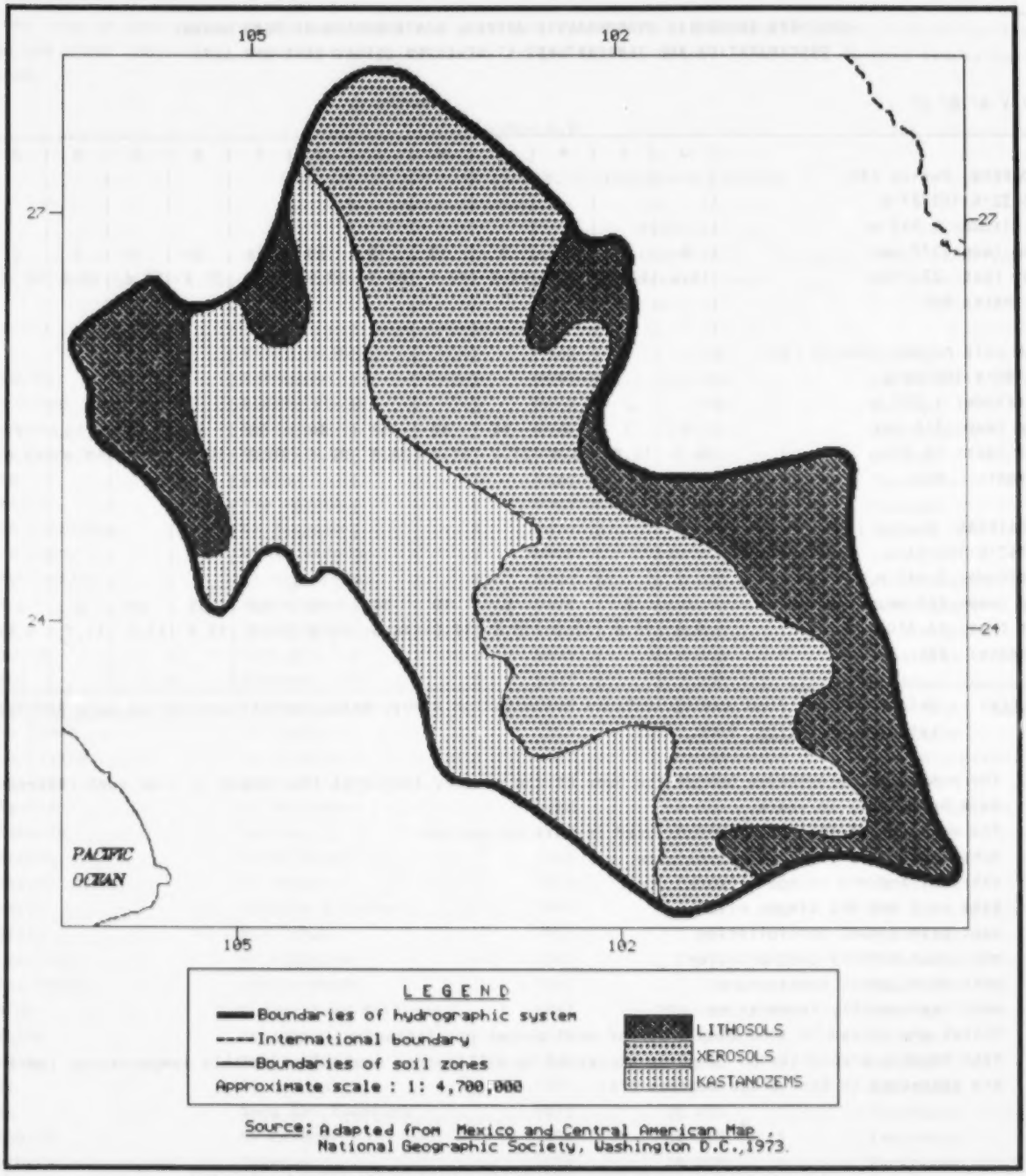
Map 4.3



Source: Adapted from Mexico and Central American Map , National Geographic Society, Washington D.C.,1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 4.4



Source: Adapted from Mexico and Central American Map, National Geographic Society, Washington D.C., 1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 4.1

SOUTHERN ENDORHEIC HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN ANNUAL PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 4.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
TORREON, Mexico (30)												
25°32'N-103°27'W												
Altitude: 1 013 m												
mmp (map: 177 mm)	6	4	2	3	13	19	30	36	35	19	5	5
mmt (mat: 22.4°C)	14.4	17.0	20.5	24.6	27.1	28.3	27.8	27.3	25.3	22.6	18.2	15.2
Climate: BWh												
SAN LUIS POTOSI, Mexico (30)												
22°09'N-100°59'W												
Altitude: 1 877 m												
mmp (map: 316 mm)	8	5	2	14	32	62	34	50	69	23	10	7
mmt (mat: 18.2°C)	14.0	15.8	18.8	21.0	21.8	21.3	20.1	20.2	19.0	17.3	15.6	13.8
Climate: BSh												
ZACATECAS, Mexico (30)												
22°47'N-102°34'W												
Altitude: 2 612 m												
mmp (map: 263 mm)	4	2	3	6	10	38	46	62	55	25	6	6
mmt (mat: 13.3°C)	9.4	10.6	12.8	15.5	17.0	16.3	14.8	14.9	13.8	13.1	11.7	9.9
Climate: BSk												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

b/ The meanings of the abbreviations used in this column are:
BWh: hot and very dry desert climate
BSk: hot and dry steppe climate
BSk: cold and dry steppe climate
map: mean annual precipitation
mmp: mean monthly precipitation
mat: mean annual temperature
mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication, information was not available concerning hydroelectric plants, oil refineries, iron and steel industries, paper and pulp industries or non-ferrous metals industries in this hydrographic system.

Table 4.2

DAMS IN THE SOUTHERN ENDORHEIC HYDROGRAPHIC SYSTEM

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3)	Purpose a/	Administrative division
(Mexico)					
...	Cinco de Mayo	1980	4 000	I	Durango
Achoquén	Achoquén	1955	20 000	I	Zacatecas
Agua Zarca	Rancho Viejo	1969	1 000	I	Durango
Aguanaval	El Cazadero	1964	30 900	I	Zacatecas
Arroyo del Muerto	Castillo del Valle	1969	800	I	Durango
Ateto	Ateto	1880	2 000	I	Zacatecas
Caballos	San Jacobo	1962	1 100	I	Durango
Casas Coloradas	El Tejamen	1979	2 500	I	Durango
Cerro Gordo	Villa Hidalgo	1977	25 000	I	Durango
Chalchihuites	El Maestranzo	1980	5 000	I	Zacatecas
Chico	Santa Rosa	1937	14 400	I	Zacatecas
Chico	C.D.D.E.E.(Cabrales)	1976	6 000	I	Zacatecas
Chihuila	Chihuila	1970	6 000	I	Zacatecas
Coneto	Miramar	1907	1 000	...	Durango
De Enmedio	Arroyo de Enmedio	1968	2 500	I	Zacatecas
De La Bomba	La Bomba	1968	2 000	I	Zacatecas
De La Rivera	La Rivera	1957	1 500	I	San Luis Potosí
De La Vaca	Los Castillo	1973	1 200	I	Durango
El Aguila	El Ahijadero	1978	4 000	I	Zacatecas
El Caballo	García	1952	2 800	I	Durango
El Grande	Bordo Boquillas	1965	1 250	I	Zacatecas
El Jaguey	El Jaguey	1975	2 500	I	Zacatecas
El Peaje	Gonzalo N.Santos	1949	9 300	S	San Luis Potosí
El Sitio	Las Tuzas	1955	1 500	I	Zacatecas
El Tecolote	El Tecolote	1970	2 000	I	Zacatecas
Encino Mocho	Encino Mocho	1967	1 400	I	Zacatecas
Florido	Federalismo Mexicano	1982	250 000	R	Durango
Garabito	Garabito	1975	3 500	I	Durango
Graceros	Santa Elena	1970	15 000	I	Durango
Jerez	El Cuidado	1870	2 600	I	Zacatecas
Jerez	Boca del Tesorero	1977	26 000	I	Zacatecas
Juchipila	El Chique	1958	64 000	I	Zacatecas
Juchipila	Tayahua	1978	38 000	I	Zacatecas
La Calera	Calera	1965	1 565	I	Zacatecas
La Cuna	La Cuna	1951	5 000	I	Zacatecas

Table 4.2 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3)	Purpose a/	Administrative division
(Mexico)					
La Presita	Palmarejo	1970	2 200	I	Zacatecas
La Sauceda	Pena del Aguila	1955	30 000	I	Durango
La Tinaja	El Carretero	1966	950	I	Zacatecas
Las Pilas	Los Ríos	1977	2 000	I	Zacatecas
Lobatos	San Isidoro de Los González	1978	7 500	I	Zacatecas
Lobera y Tigre	Las Lajas	1920	1 150	I	Durango
Los Conejos	El Salto	1865	1 350	I	Zacatecas
Los Lazos	Leobardo Reynoso	1949	75 000	I	Zacatecas
Los Mimbres	El Progreso	1971	830	I	Durango
Machines	Las Chilitas	1958	3 600	I	Zacatecas
Nazas	Lazaro Cárdenas	1947	3 162 000	I,C	Durango
Nazas	Francisco Zarco	1969	438 000	I,C	Durango
Palomas	Palomas	1970	8 000	I	Zacatecas
Palomas	Encarnacion	1976	8 000	I	Zacatecas
Peñasco	El Peñasco	1970	1 300	I	Zacatecas
Poanas	Gral.Francisco Villa	1968	101 000	I	Durango
Rosales y San Lucas	Rosales	1970	5 000	I	Zacatecas
S.María de La Paz	El Izote	1968	1 000	I	Zacatecas
Saladillo	El Cantil	1966	1 250	I	Zacatecas
San Antonio	Sn.Antonio de Padua	1976	3 000	I	Zacatecas
San Cristóbal	Jose Balderas G.	1975	3 000	I	Zacatecas
San Jerónimo	Pedernalillo	1952	6 000	I	Zacatecas
San Pedro	San Pedro Piedra Gorda	1957	2 000	I	Zacatecas
Santiago	San Jose	1905	8 000	S	San Luis Potosí
Seco	La Cantera	1964	1 530	I	Durango
Sta.Clara	Sn.Antonio de La Laguna	1964	4 210	I	Durango
Susticacán	Susticacán	1965	4 500	I	Zacatecas
Temporales	Los Temporales	1962	15 000	I	Durango
Tenango	Tenango	1957	1 100	I	Zacatecas
Tepetongo	Las Víboras	1948	2 000	I	Zacatecas
Tlaltenango	Miguel Alemán	1949	71 200	I,H,C	Zacatecas
Tunal	Pte.Guadalupe Victoria	1962	81 000	I,C,S	Durango
Varias	Montoro	1890	1 000	I	Zacatecas
Villanueva	Chicimostoc	1980	6 000	I	Zacatecas
Yerbabuena	Sn.Pedro Piedra Gorda	1981	5 000	I	Zacatecas
Yerbanis	Bordo Veinte Amigos	1960	2 000	I	Durango
Zaragoza	Dolores	1975	4 500	I	Zacatecas
			4 628 485		

Total - Hydrographic system : 4 628 485

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Symbols used in "Purpose" column:

C: Flood control
H: Hydroelectricity
I: Irrigation
N: Navigation
R: Recreational purposes
S: Water supply

Table 4.3

SOUTHERN ENDORHEIC HYDROGRAPHIC SYSTEM: THERMOELETRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Mexico)				
Nazas	Francke	60.0	Durango	Gómez Palacio
Nazas	La Laguna	129.0	Durango	Gómez Palacio
Nazas	Torreón	28.0	Coahuila	Torreón
	Total - Hydrographic system:	217.0		

Source: ECLAC, on the basis of official data.

Table 4.4

SOUTHERN ENDORHEIC HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

River or body of water	City	Population				Administrative division
		1950	1960	1970	1980	
(México)						
...	San Luís Potosí	125 662	193 670	274 320	327 333	San Luis Potosí
Nazas	Gómez Palacio	45 873	103 544	135 743	103 001	Durango
Nazas	Torreón	128 971	203 153	257 045	407 271	Coahuila

Source: James W. Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin American Center Publications, University of California, 1981, and ECLAC, on the basis of official figures.

Table 4.5

SOUTHERN ENDORHEIC HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960		1970		1980	
		Population	Density	Population	Density	Population	Density
(Mexico) a/							
Coahuila	68 207	408 480	6.0	501 730	7.4	700 769	10.3
Durango	65 806	418 460	6.4	516 564	7.8	650 276	9.9
Nuevo León	16 139	269 712	16.7	423 672	26.3	632 761	39.2
San Luis Potosí	37 709	628 978	16.7	769 198	20.4	1 004 336	26.6
Zacatecas	48 776	531 590	10.9	618 450	12.7	738 939	15.1
Total - Hydrographic system :	236 637	2 257 220	9.7	2 829 615	12.6	3 727 082	17.1

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras, 1974, Situación demográfica: estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

a/ Dates of censuses: 08-06-60, 28-01-70, 04-06-80.

V. GULF OF MEXICO HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The Gulf of Mexico hydrographic system covers a large part of eastern Mexico and the whole of north-western Guatemala, and has an area of approximately 473 073 km^2. Going from north to south, it encompasses parts of the states of Tamaulipas, Nuevo León, San Luis Potosí, Guanajuato, Querétaro, México, Tlaxcala, Puebla, Oaxaca and Chiapas and the whole of the states of Hidalgo, Veracruz and Tabasco. In Guatemalan territory, its takes in part of the departments of San Marcos, Quetzaltenango, Totonicapán, Baja Verapaz, Alta Verapaz, Petén and the whole of Huehuetenango and Quiché. The largest surface watercourses are those of the Pánuco river system, which flows into the Gulf at Ciudad Madero; the Papaloapán River to the south of the city of Veracruz; and the large water system formed by the Grijalva and Usumacinta rivers in the extreme south. Its western boundary is formed by the Sierra Madre Oriental, the Sierra Madre del Sur and the Sierra de Chacús in the central portion of Guatemala. The co-ordinates demarcating this system are 15° and 24°30' north latitude and 89°30' and 101°30' west longitude; the system's configuration is generally along a NW-SE diagonal (see map 5.1).

2. Climate

a) Climate types (Köppen classification): The entire Gulf of Mexico hydrographic system is subject to the influence of subtropical cyclones and anticyclones, especially during the winter and the spring, when these storms shift southward. When they move northward again during the summer and autumn, then tropical cyclones originating in the area of the Gulf and the Pacific become the predominant weather factor. This synoptic pattern, together with the orographic barrier rising to the west (Sierra Madre Oriental), gives rise to climates ranging from temperate and even arid in the north and north-west of the system to very wet tropics in the south. In the southern half of the system three main types of rainy tropical climates predominate (Af, Am and Aw). In the northern half, along the coast, the predominant climate is rainy

and tropical, with the rainfall in the summer (Aw); as the altitude increases further inland, the climate becomes temperate (type C) and then arid (type B) near the boundary of the Northern Pacific hydrographic system (states of Tlaxcala, México, Querétaro, Guanajuato and San Luis Potosí). Thus, the aridity factor diminishes in a WNW-ESE direction (see map 5.2).

b) Precipitation: The air masses moving in from over the Atlantic Ocean, i.e., the Trade Winds, reach as far as about 100° west longitude in the winter (January); during the summer (July), these winds become monsoons and penetrate into the whole of Mexican territory. This contrast between the invasion of dry air masses in the winter and humid air masses in the summer exerts a very strong influence over the rainfall pattern of the Gulf of Mexico hydrographic system. The result is a total of five different internally homogenous and clearly-defined precipitation zones.

The first zone is semi-arid and covers the entire northern part of the State of Mexico. Mean annual precipitation varies between 250 and 700 mm and is chiefly due to convection and orographic effects. Precipitation is sometimes brought on by the jet stream, descending air masses or frontal systems during the winter and by lines of confluence, tropical waves or the secondary effects of tropical cyclones during the summer.

The second zone stretches along the northern and western portions of the hydrographic system, breaks off at the Isthmus of Tehuantepec, and then recommences over the mountainous terrain separating the Grijalva and Usumacinta rivers in the state of Chiapas. Within this zone, the amount of precipitation increases as one moves from north to south and from west to east, and ranges from 250 mm annually in inland areas to 3 000 mm in the southern and central portions of the zone. Convectional and orographic effects account for most of the rainfall. Subtropical systems often produce precipitation in the winter. In the summer, lines of confluence, tropical waves and tropical cyclones bring rain to the area.

The third zone surrounds the second zone and covers a lengthwise strip between the coast and the mountains to the west. The large quantity of precipitation (over 1 000 mm and up to more than 3 000 mm in some micro-zones) observed in this area occurs mainly during the winter and is due to the passage of weather fronts. In the summer, rainfall is caused by tropical waves, lines of confluence and tropical cyclone disturbances.

The fourth rainfall zone encompasses the entire coastal strip of the hydrographic system south of 22° north latitude. Throughout the central coast of the Gulf of Mexico the amount of rainfall totals about 2 000 mm, increasing up to 3 000 mm in the coastal sector of the isthmus of Tehuantepec. The sources of precipitation are the frontal systems which form in the winter, combined with

strong northerly winds. These factors account for the increased precipitation observed in the State of Chiapas in the vicinity of the intertropical convergence zone (ICZ), which is the principal source of the rainstorms that occur during the summer months.

The fifth rainfall zone corresponds to an E-W strip along the border between the southern Mexican states of Tabasco and Chiapas which stretches from the extreme eastern part of the system to the Isthmus of Tehuantepec. Precipitation in this zone exceeds 2 000 mm due to the area's orographic characteristics and geographic position. In winter, weather fronts and pre-frontal waves produce abundant rainfall. In the summer, the predominantly north-easterly winds have a direct influence on the area and, together with tropical waves and the effects of hurricanes and other tropical disturbances, bring a substantial amount of precipitation to this zone (see map 5.3 and table 5.1).

c) Temperature: Practically all of this hydrographic system lies to the south of the Tropic of Cancer in a zone characterized by mean monthly temperatures above 18°C in the areas under 1 000 m above sea level and in which the annual temperature variation diminishes from approximately 10°C in the north (the city of Tampico) to less than 5°C in the extreme south (the city of Tuxtla Gutiérrez). Temperatures gradually decline from east to west as the altitude increases; the temperature patterns in the inland portions of the system differ from those of the rest of the system as far as the annual temperature variation is concerned. This variation diminishes from north to south as one approaches the Equator. The harshest climate in terms of lower temperatures and greater annual temperature fluctuations is in the north-western part of the system along this system's boundary with the northern Pacific hydrographic system, while the most stable zones having the highest mean monthly temperatures are found along the south-eastern coast (State of Tabasco) and in northern Guatemala (see table 5.1).

3. Geomorphology and soils

The main physiographic units in this hydrographic system are the Sierra Madre Oriental; the isthmus region and the Sierra Madre de Chiapas; and the Gulf of Mexico coastal plains.

The Sierra Madre Oriental runs along the western edge of the system up to the Isthmus of Tehuantepec. This range is composed chiefly of Mesozoic and Cainozoic rock; volcanoes, whose upper layers are formed by tuff and lava, exist only in the middle portion of this range. The denudation process is very slight in this area due to the plant cover.

The mountainous terrain extending downward from the north-west gives way to lower altitudes in the region of the isthmus, where the extensive alluvial plains are formed by fill made up of

sediments from the Mesozoic, Pleistocene and Holocene. The Sierra Madre de Chiapas (a prolongation of the Sierra Madre del Sur) runs south-east from its starting point at 95° west longitude. This range is predominantly made up of ancient intrusive igneous rocks associated with Paleozoic sedimentary rock and some volcanic rock from the Cainozoic, and extends into Guatemala in the form of volcanic highlands.

The Sierra Madre Oriental continues as the Sierra del Norte de Chiapas and, in Guatemala, as the Cordillera de los Cuchumatanes. Between these two ranges lies a central depression (the Grijalva river valley) which extends up to the continental divide in Guatemala. The altitude increases to the south-east, where it varies between 2 000 and 3 000 metres above sea level.

The Gulf of Mexico coastal plains are made up of sedimentary rock, which is older at the higher altitudes. The relief of the area is of a slightly sloping plain in the inland section and flatter plains in the vicinity of the coast. This area does not exhibit any tectonic activity, except in some parts of the central and southern portions of the State of Veracruz, which are seismic and peni-seismic zones due to the influence of the tectonic region of western Mexico.

A number of different soil types are found in the system, namely:

i) Cambisol and acrisol soils, which are the result of intense weathering and are associated with wet climates (Aw, Am and Cf). These soils are found virtually throughout the coastal plain and on the eastern slopes of the Sierra Madre Oriental in the State of Veracruz and the north-eastern portion of the State of Oaxaca, as well as on the northern slope of the Sierra del Norte de Chiapas.

ii) Andosol soils, produced by low-intensity weathering are found in areas having tropical rainy climates in which the rain falls during the summer (Aw). These soils occur in the coastal plains of the state of Veracruz and in the state of Puebla.

iii) Gleysol and fluvisol soils are found in the swamplands produced by the frequent flooding of the rivers in the southern section of the slope leading down to the Gulf of Mexico, i.e., the Coatzacoalcos, Papaloapán, Grijalva and Usumacinta rivers. These soils are associated with very rainy tropical climates (Af and Am). They occur in the State of Tabasco, south-eastern Veracruz, north-eastern Chiapas and north-western Guatemala.

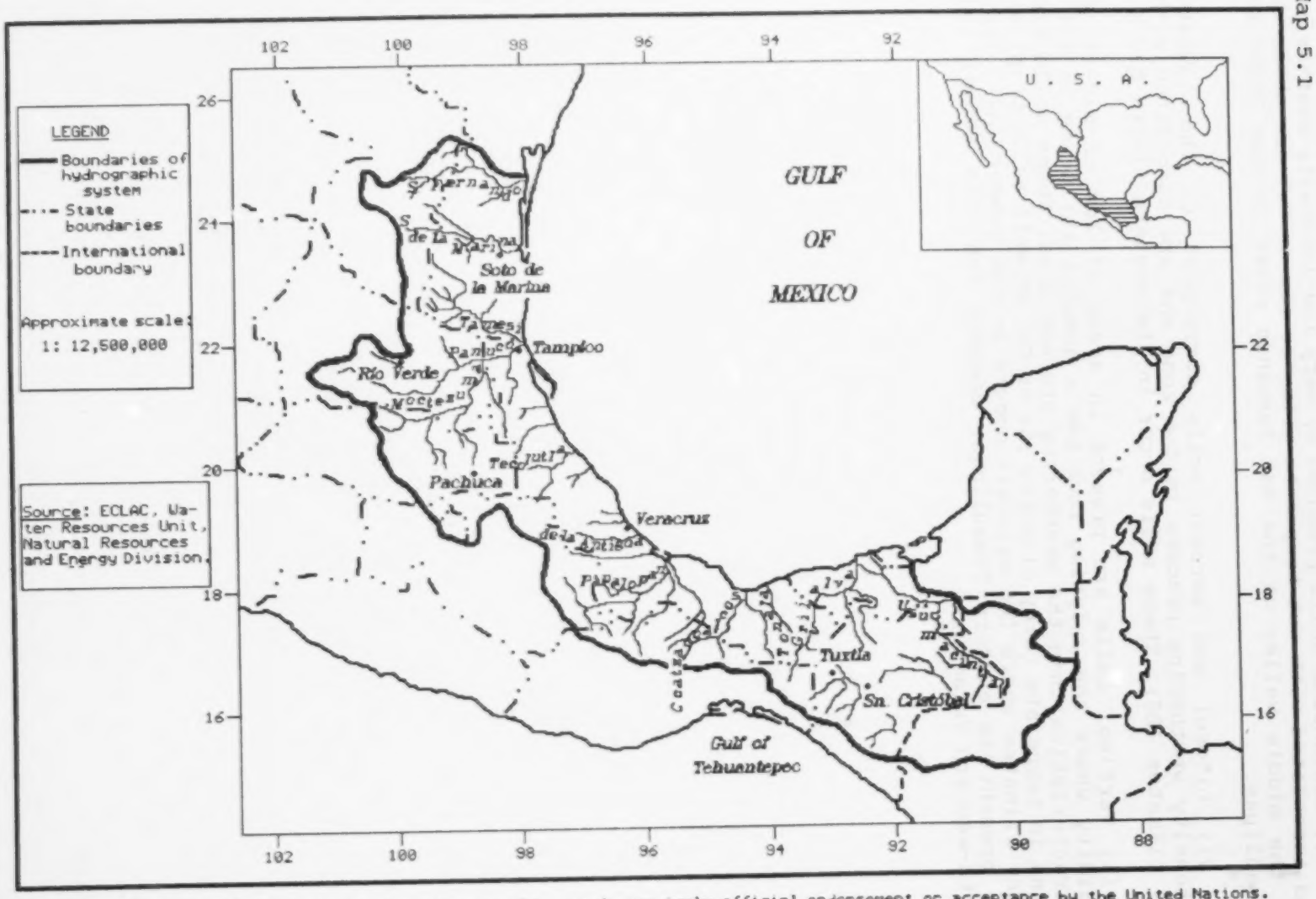
iv) Luvisol soils originating from a low-intensity weathering process and associated with rainy temperate climates (Cf and Cw) are found in the Sierra Madre Oriental and the Sierra Madre de Chiapas.

v) Kastanozem soils produced by very low-intensity weathering and associated with wet temperate climates (Cx or Cw) are observed in the middle valley of the San Fernando river in the State of Tamaulipas.

vi) Litosol and xerosol soils correspond to the lowest-intensity weathering process in the zone and are associated with dry climates (BS). These soils occur in the western Sierra Madre.

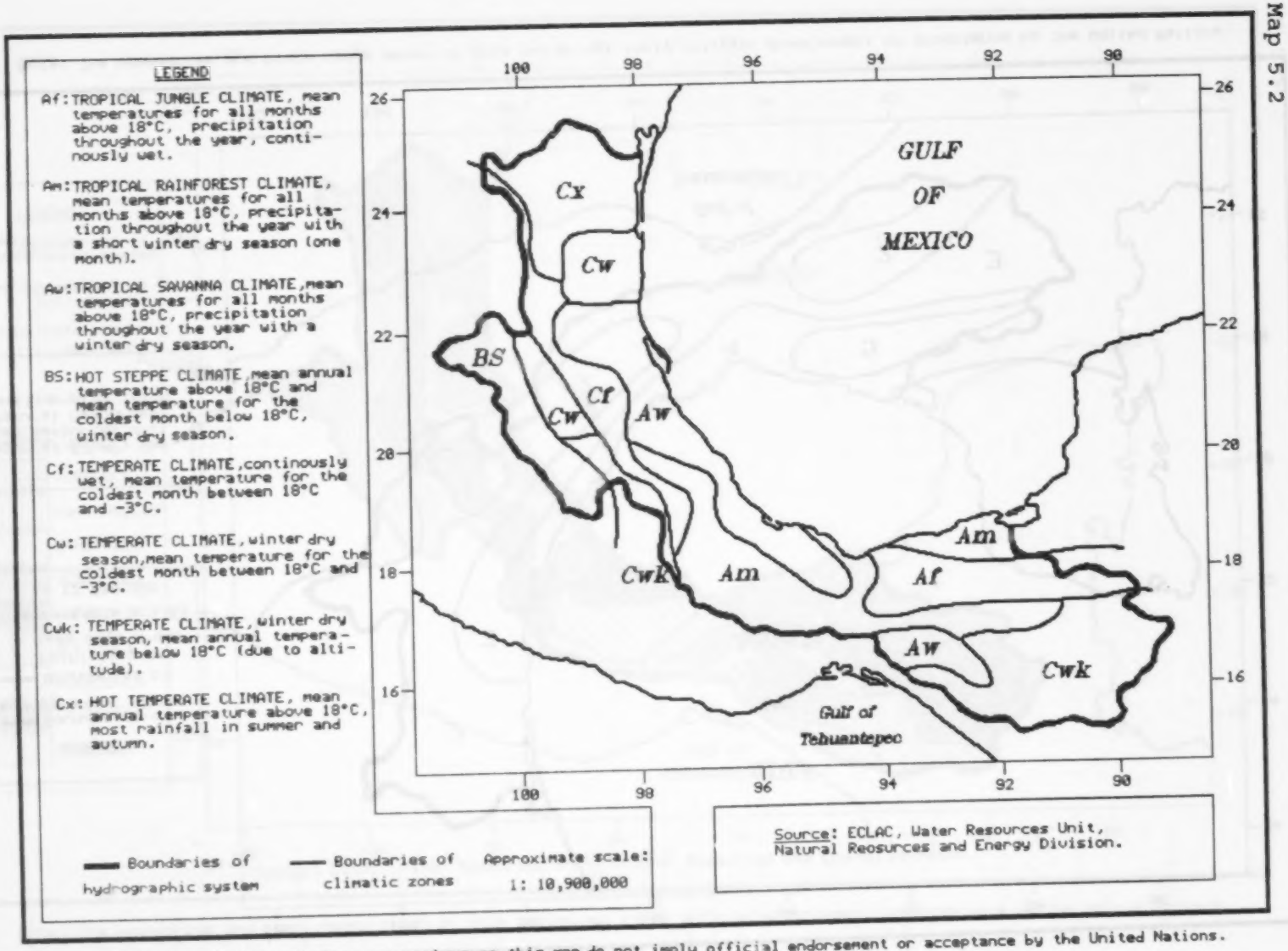
vii) Vertisol soils are present in areas of low or mid-range humidity where the existing rock has a greater influence on soil characteristics than the weathering process does. These soils are found in temperate rainy climates (Cx or Cw) as well as in tropical rainy climates where the rainfall occurs in the summer (Aw). They are present in eastern Tamaulipas, eastern San Luis Potosí and north-western Veracruz.

Map 5.1



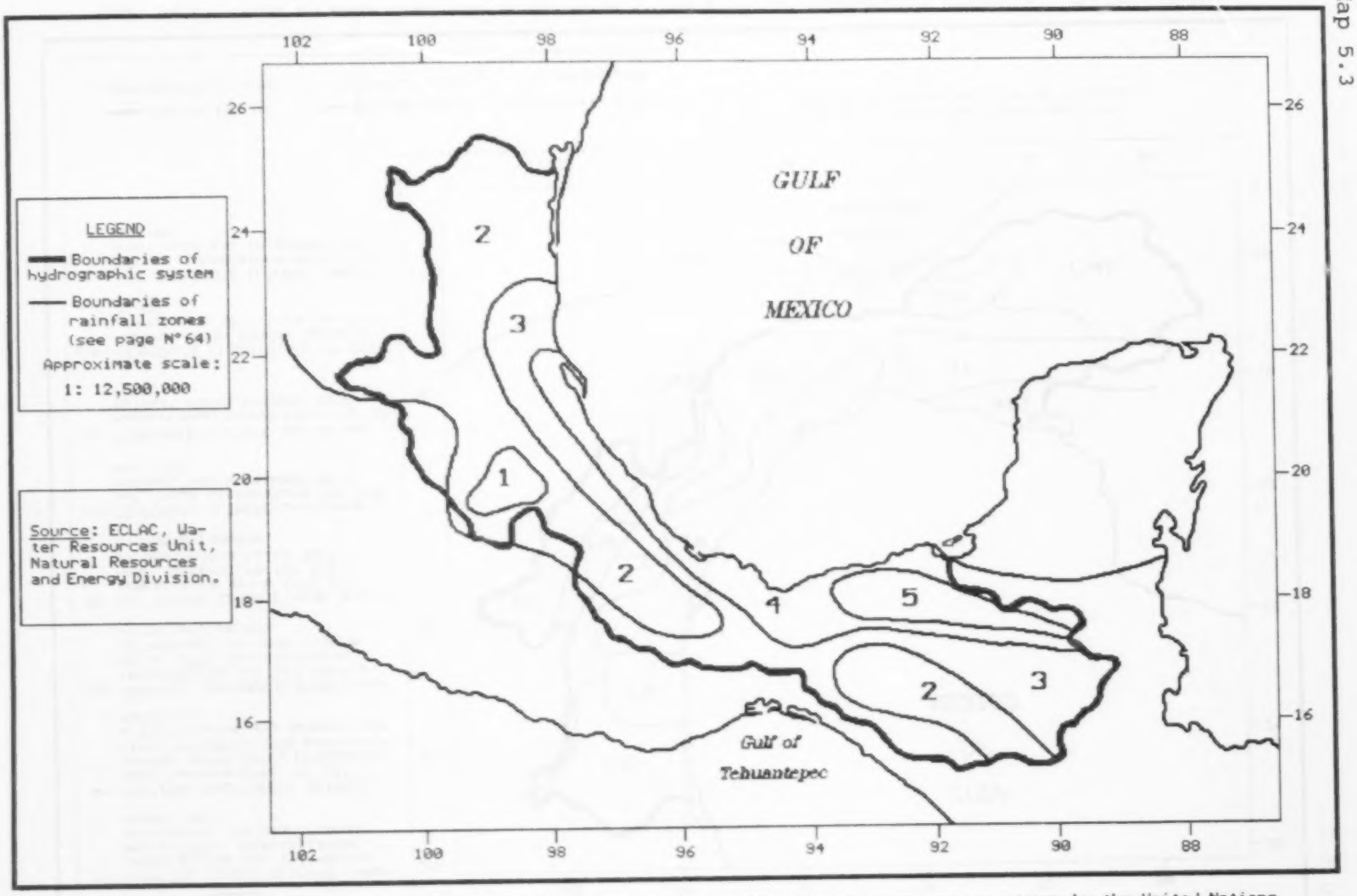
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 5.2


LEGEND
Af: TROPICAL JUNGLE CLIMATE, mean temperatures for all months above 18°C, precipitation throughout the year, continously wet.
Am: TROPICAL RAINFOREST CLIMATE, mean temperatures for all months above 18°C, precipitation throughout the year with a short winter dry season (one month).
Aw: TROPICAL SAVANNA CLIMATE, mean temperatures for all months above 18°C, precipitation throughout the year with a winter dry season.
BS: HOT STEPPE CLIMATE, mean annual temperature above 18°C and mean temperature for the coldest month below 18°C, winter dry season.
Cf: TEMPERATE CLIMATE, continously wet, mean temperature for the coldest month between 18°C and -3°C.
Cw: TEMPERATE CLIMATE, winter dry season, mean temperature for the coldest month between 18°C and -3°C.
Cwk: TEMPERATE CLIMATE, winter dry season, mean annual temperature below 18°C (due to altitude).
Cx: HOT TEMPERATE CLIMATE, mean annual temperature above 18°C, most rainfall in summer and autumn.
GULF OF MEXICO
Cx
Cw
BS
Cf
Cw
Aw
Am
Af
Am
Aw
Cwk
Cwk
Gulf of Tehuantepec
100
98
96
94
92
90
26
24
22
20
18
16
Boundaries of hydrographic system
Boundaries of climatic zones
Approximate scale: 1: 10,900,000
Source: ECLAC, Water Resources Unit, Natural Reosurces and Energy Division.

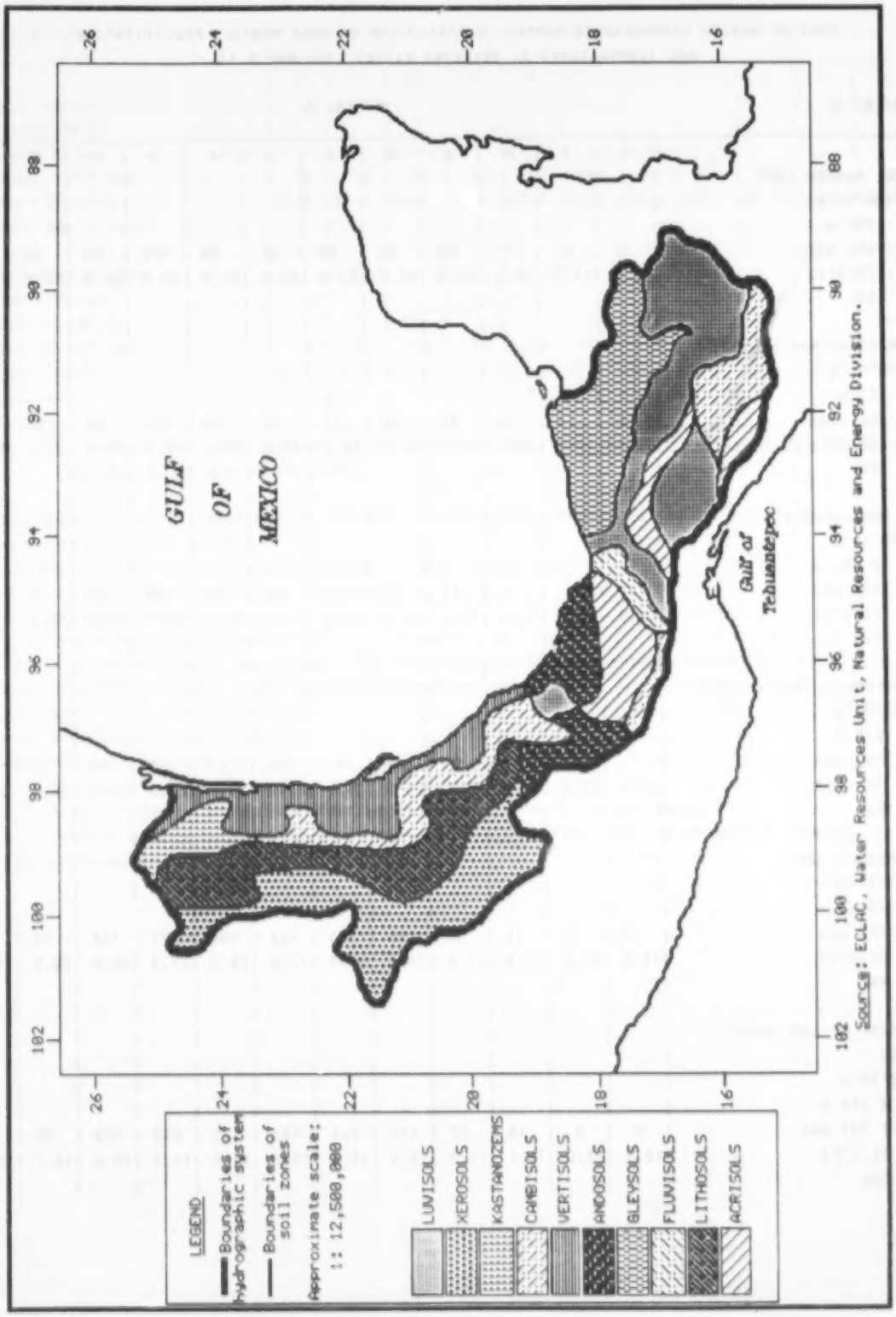
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 5.3



Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 5.4



Source: ECLAC, Water Resources Unit, Natural Resources and Energy Division.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 5.1

GULF OF MEXICO HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 5.1)

Cities a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
RIO VERDE, Mexico (30)												
21°56'N-100°00'W												
Altitude: 987 m												
mmp (map: 484 mm)	10	6	7	20	32	79	63	78	104	57	18	10
mmt (mat: 20.9°C)	15.3	17.7	20.3	23.3	24.9	25.0	24.0	24.0	22.8	20.3	17.7	15.8
Climate: BS												
SOTO LA MARINA, Mexico (30)												
23°46'N-98°12'W												
Altitude: 25 m												
mmp (map: 641 mm)	18	16	16	32	44	101	60	58	151	98	32	15
mmt (mat: 24.2°C)	17.5	19.4	22.5	25.5	27.5	28.9	28.8	29.1	27.5	24.6	21.4	18.2
Climate: Cx												
PACHUCA, Mexico (30)												
20°08'N-98°44'W												
Altitude: 2 426 m												
mmp (map: 373 mm)	11	6	11	31	39	65	44	48	68	32	12	6
mmt (mat: 14.2°C)	12.0	13.3	15.4	16.4	16.1	15.4	14.5	14.7	14.1	13.5	12.6	12.1
Climate: Cwk												
TUXTLA GUTIERREZ, Mexico (30)												
16°45'N-93°07'W												
Altitude: 528 m												
mmp (map: 849 mm)	1	1	19	9	68	185	148	159	188	59	12	-
mmt (mat: 24.4°C)	22.2	23.0	25.0	26.2	26.8	25.5	25.2	25.1	24.8	24.0	23.0	22.2
Climate: Aw												
TAMPICO, Mexico (26)												
22°13'N-97°51'W												
Altitude: 12 m												
mmp (map: 972 mm)	20	14	14	18	36	153	128	104	271	127	51	36
mmt (mat: 24.2°C)	18.5	20.0	21.8	24.8	26.8	27.5	27.9	28.2	27.3	26.0	22.2	19.9
Climate: Aw												
SAN CRISTOBAL DE LAS CASAS, Mexico (30)												
16°44'N-92°38'W												
Altitude: 2 276 m												
mmp (map: 1 201 mm)	8	8	18	57	116	241	166	175	242	122	35	13
mmt (mat: 14.4°C)	12.3	13.0	14.1	15.2	15.4	15.6	15.7	15.6	15.2	14.4	13.7	12.3
Climate: Cwk												

Table 5.1 (concl.)

City a/ b/ c/ — Months d/

	E	F	M	A	M	J	J	A	S	O	N	D
VERACRUZ, Mexico (26)												
19°12'N-96°08'W												
Altitude: 16 m												
mmp (map: 1 747 mm)	23	16	29	21	57	287	400	303	354	156	62	39
mmt (mat: 25.4°C)	21.5	22.1	23.4	25.8	27.4	28.0	27.8	28.2	27.7	26.5	24.3	22.6
Climate: Aw												
ORIZABA, Mexico (30)												
18°51'N-97°06'W												
Altitude: 1 284 m												
mmp (map: 2 118 mm)	42	34	34	41	119	396	422	354	357	200	76	43
mmt (mat: 19.2°C)	16.1	17.1	19.2	21.2	21.6	21.1	20.2	20.6	20.3	19.0	17.5	16.5
Climate: Cf												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

b/ The meanings of the abbreviations used in this column are:
Aw: tropical savanna climate, dry season in winter
Bs: steppe climate
Cf: temperate rainy climate, rainfall throughout the year
Cwk: temperate climate, dry season in winter, mean annual temperature below 18°C (due to altitude)
Cx: temperate climate, light rainfall throughout the year
map: mean annual precipitation
mmp: mean monthly precipitation
mat: mean annual temperature
mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication, information was not available on thermoelectric plants in this hydrographic system.

Table 5.2

DAMS IN THE GULF OF MEXICO HYDROGRAPHIC SYSTEM

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Guatemala)					
Chixoy	Pueblo Viejo	1983	485 000	H	Alta Verapaz
	Total Guatemala :		485 000		
(Mexico)					
Acayuca	Huatongo	1962	1 850	I	Hidalgo
Actopán	Debode	1936	6 950	I	Hidalgo
Aguafría	Capucín del Batán	1911	2 080	I	Querétaro
Alaquines	Alvaro Obregón (Palomas)	1939	4 000	I	San Luis Potosí
Alfajayucan	Vicente Aguirre	1950	21 000	I	Hidalgo
Alfajayucan	Javier R.Gómez	1979	42 300	I	Hidalgo
Apaxtla	La Laguna	1912	43 500	H	Hidalgo
Apulco	La Soledad	1962	60 000	H	Puebla
Arroyo Zarco y El Rosal	El Molino	1880	7 700	I	Mexico (State)
Arroyo Colorado	Arroyo Colorado	1975	1 200	I	Hidalgo
Arroyo Seco	Ing.Fco.Osorno	1975	1 000	I	Hidalgo
Arroyo Sordo	El Sordo	1960	500	C	Mexico (State)
Axocapa	La Cañada	1962	2 100	I	Tlaxcala
Blanco	Tuxpango	1932	500	H	Veracruz
Casandeje	Cuendo	1958	390	I	Mexico (State)
Ceja de Bravo	Ceja de Bravo	1955	4 500	I	Querétaro
Chicayán	Chicayán	1976	570 000	I,C	Veracruz
Chico de Tulancingo	La Esperanza	1943	4 200	I	Hidalgo
Coacuila y Matzontla	Tenango	1910	43 100	H	Puebla
Cristo y Mayorazgo	Embajomuy	1942	1 400	I	Mexico (State)
Cuautitlán	Guadalupe	1968	66 000	I,C,S	Mexico (State)
Cuxtepeques	El Portillo II	1980	1 000 000	I,C	Chiapas
De La Vega	Macua	1963	4 250	I	Hidalgo
Del Puerto	Tlaxcalilla	1980	1 100	I	Hidalgo
El Capulín	El Capulín de Amealco	1960	5 370	I	Querétaro
El Caracol	Constitución de 1917	1969	65 000	I,C	Querétaro
El Pinal	El Carmen	1958	5 140	I	Querétaro
El Quelite	Los Quelites	1966	1 150	I	Mexico (State)
El Sauz	La Loma	1968	1 200	I	Hidalgo
El Yathe	El Yathe	1923	670	I	Hidalgo
García	El Coto	1903	1 400	I	Querétaro
Grijalva	Netzahualcoyotl	1964	8 300 000	H,C	Chiapas

Table 5.2 (cont.1)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
Grijalva	La Angostura	1974	9 200 000	H	Chiapas
Grijalva	Manuel M.Torres	1980	1 613 000	H	Chiapas
Grijalva	Penitas	1985	1 485 000	H	Tabasco
Hondo	Madero	1939	37 000	I	Hidalgo
Huimilpán	San José Huimilpán	1965	1 000	I	Querétaro
Huimilpán	San Pedro Huimilpán	1970	5 000	I	Querétaro
La Bufa	La Concepción	1963	3 200	I	Mexico (State)
La Mina	La Mina	1967	1 000	I	Oaxaca
La Mora	El Girón	1940	1 450	I	Hidalgo
La Mula	Nuevo Bordo	1963	600	I	Querétaro
La Vega	El Sabino	1970	2 000	I	Hidalgo
La Vega	La Goleta	1981	2 000	I	Mexico (State)
Las Animas	San Carlos	1934	1 490	...	Hidalgo
Las Lajas	José Trinidad Fabela	1945	6 500	I	Mexico (State)
Las Maravillas	El Centenario	1973	1 100	I	Tlaxcala
Los Cuartos	Los Cuartos	1961	1 150	C	Mexico (State)
Los Reyes	Los Reyes	1910	26 100	H	Puebla
Los Reyes	Los Reyes	1965	6 200	I	Guanajuato
Mixcoac	Mixcoac	1941	910	C	Federal District
Monte Alto	Iturbide	1961	1 500	I	Federal District
Necaxa	Necaxa	1909	43 000	H	Puebla
Omitlán	San Vicente	1960	500	I	Hidalgo
Pachuca	Los Manantiales	1960	2 660	C	Hidalgo
Papaloapán	El Aguila	1968	1 000	I	Oaxaca
Papaloapán	El Capulín	1970	1 000	I	Oaxaca
Peña Alta	Peña Alta	1973	4 000	I	Hidalgo
Prieto	San Ildefonso	1942	52 300	I,C	Querétaro
Puentezuela	El Guarda	1972	550	I	Mexico (State)
Rancho Nuevo	Rancho Nuevo	1977	800	I	Hidalgo
S.Luis de Las Peras	Taxhimay	1934	50 000	I	Hidalgo
S.María y Zamorano	La Soledad	1969	8 000	I	Querétaro
San Andrés	Los Angeles	1960	4 500	I	Hidalgo
San Bartolo	El Capulín	1961	2 300	I	Mexico (State)
San Bartolo	La Chirimoya	1977	5 500	I	Guanajuato
San Francisco	El Barrial	1975	50 000	I	Guanajuato
San Joaquín	San Joaquín	1944	500	C	Mexico (State)
San José	Pozuelos	1964	946	I	Tlaxcala
San Miguel	Epigmenio González	1967	2 000	I	Querétaro
San Nicolás	El Mortero	1953	600	I	Mexico (State)
San Nicolás	La Golondrina	1978	28 000	I	San Luis Potosí
San Pedro	San Pedro	1971	600	I	Hidalgo
San Pedro El Alto	San Pedro El Alto	1970	1 000	I	Mexico (State)
Santa Ana	La Soledad	1955	2 400	S	Guanajuato
Santa Bárbara	La Palma	1975	525	I	Hidalgo
Santa María	Ojo Caliente	1968	10 000	I	San Luis Potosí
Santa Rosa	Leon Guzmán	1972	630	I	Mexico (State)
Santiaguillo	Santiaguillo	1961	2 000	I	Guanajuato

Table 5.2 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
Seco	José Fco.Osorno	1971	1 400	I	Hidalgo
Silao	Chichimequillas	1973	15 000	C	Guanajuato
Sta.Lucía y Ladrones	Santa Lucía	1959	1 340	I	Hidalgo
Tacubaya	Tacubaya	1938	149 000	C	Federal District
Tambula	Tambula	1956	1 300	I	Guanajuato
Tapaxco	El Salto	1961	550	I	Mexico (State)
Tarimoro	El Cubo	1978	10 500	I	Guanajuato
Teapa	La Cangrejera	1980	18 500	S	Veracruz
Tenasco	Alvaro Obregón(El Gallinero)	1946	13 000	I,S	Guanajuato
Tenexac	Tenexac	1973	2 000	I	Tlaxcala
Teometitla	Teometitla	1967	1 600	I	Tlaxcala
Tepetitlán	Tepetitlán	1964	70 000	I	Mexico (State)
Tepotzotlán	La Concepción	1949	12 500	I,C	Mexico (State)
Tepozán	El Tezoyo	1949	11 200	I	Hidalgo
Tigre	Las Adjuntas	1961	6 000	I	Guanajuato
Tigres	Cebolletas	1963	6 300	I	Guanajuato
Tilcuautla	El Durazno	1970	2 600	I	Hidalgo
Tilostoc	Ixtapántongo	1950	1 900	H	Mexico (State)
Tilostoc	Santo Tomás	1957	8 900	H	Mexico (State)
Tiradores	Tiradores	1969	1 240	I	Veracruz
Tlalnepantla	Madin	1976	18 900	S,C	Mexico (State)
Tlautla	Danxho	1949	22 600	I,C	Mexico (State)
Tomata	El Encanto	1948	0	H	Veracruz
Tonto	Presidente Alemán	1955	6 515 000	I,H,C	Oaxaca
Tortugas	Metepec	1964	6 300	I	Hidalgo
Totolac	Recoba	1962	1 650	I	Tlaxcala
Totolica	Totolica	1963	1 900	C	Mexico (State)
Tr.Papaloapán	Tilcajete	1973	500	...	Oaxaca
Tula	Endo	1951	182 000	I	Hidalgo
Tula y El Salto	Requena	1922	71 000	I,C	Hidalgo
Valle de Bravo	Valle de Bravo	1944	400 000	H	Mexico (State)
Victoria	Mision de Arnedo	1977	5 000	I	Guanajuato
Xaltepuxtla	Nexapa	1910	15 500	H	Puebla
Xiacayucan	Atexcaco	1964	0	H	Puebla
Xindho	Tagui	1977	1 050	I	Hidalgo
Zahuapán	San José Atlanga	1959	54 500	I	Tlaxcala
Zarco	San Antonio	1765	3 000	I	Mexico (State)
		Total - México :	30 574 791		
		Total- Hydrographic system :	31 059 791		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Dams for which no reservoir capacity is given are lateral dams.
b/ Symbols used in "Purpose" column:
C: Flood control I: Irrigation
H: Hydroelectricity S: Water supply

Table 5.3

GULF OF MEXICO HYDROGRAPHIC SYSTEM: HYDROELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Guatemala)				
Chixoy	Chixoy	300.0	Alta Verapaz	Sn Cristobal, Verapaz
	Total Guatemala :	300.0		
(Mexico)				
Blanco	Tuxpango	36.0	Veracruz	Ixtaczoquitlan
Grijalva	La Angostura	540.0	Chiapas	Acala
Grijalva	Malpaso	720.0	Chiapas	Tecpatan
Lago Texcoco/Tula	Valle de México	750.0	México	Acolman
Necaxa	Necaxa	115.0	Puebla	Huanchinango
Necaxa	Patla	46.0	Puebla	Zihuatentla
Necaxa	Tepex	45.0	Puebla	Huanchinango
San Juan	Chilapán	26.0	Veracruz	Catemaco
Tlatauqui	Mazatepec	209.0	Puebla	Tlantan Quitepec
	Total - Mexico :	2 487.0		
	Total - Hydrographic system :	2 787.0		

Source: ECLAC, on the basis of official data.

Table 5.4

GULF OF MEXICO HYDROGRAPHIC SYSTEM: OIL REFINERIES

River or body of water	Name of refinery	Barrels per day	Administrative division	Locality
(Mexico)				
Cazones	Poza Rica	27 000	Veracruz	Poza Rica
Coatzacoalcos	Minatitlán	270 000	Veracruz	Minatitlán
Gulf of Mexico	Ciudad Madero	175 000	Tamaulipas	Ciudad Madero
Lago Texcoco/Tula	Azcapotzalco	105 000	Federal District	Azcapotzalco
Tula	Tula	150 000	Hidalgo	Tula
	Total - Hydrographic system :	727 000		

Source: ECLAC, on the basis of data compiled by the Latin American Energy Organization (OLADE), 1979.

Table 5.5

GULF OF MEXICO HYDROGRAPHIC SYSTEM: IRON AND STEEL INDUSTRIES

River	Name of industry	Output (tons)	Administrative division	Locality
(Mexico)				
Jamapa	Tubos de Acero de Mexico TAMSA	400 000	México	Veracruz
Zavapán	Atlax S.A.	80 000	Tlaxcala	San Cosme Xalostoc
	Total - Hydrographic system:	480 000		

Source: ECLAC, on the basis of data compiled by the Latin American Iron and Steel Institute (ILAFA), 1974.

Table 5.6

GULF OF MEXICO HYDROGRAPHIC SYSTEM: PAPER AND PULP INDUSTRIES

River or body of water	Name of industry	Output (tons/year) Pulp	Paper	Locality	Administrative division
(Mexico)					
...	Cartonera Moderna	-	20 500	Uaucalrán de Juárez	Mexico (State)
...	La Sobana	5 100	-	San Pedro Xalostoc	Mexico (State)
...	Láminas Acanaladas Inf.	-	6 500	Santa Clara	Mexico (State)
...	Pasta y Pulpa	6 000	-	Santa Clara	Mexico (State)
Blanco	Celulosa Crazabana	4 740	-	Orizaba	Veracruz
Lago Texcoco/Tula	Cartón Estrella	-	75 000	Mexico City	Federal District
Lago Texcoco/Tula	Cartón y Papel de México	20 400	72 500	Los Reyes	Mexico (State)
Lago Texcoco/Tula	Cartonera Guadalupe	-	2 500	Los Reyes	Mexico (State)
Lago Texcoco/Tula	Celulosa Papel del Golfo	3 000	5 500	San Rafael	Mexico (State)
Lago Texcoco/Tula	Celulosa de Navío	3 000	-	Los Reyes	Mexico (State)
Lago Texcoco/Tula	Celulosa de Veracruz	2 000	3 000	San Rafael	Mexico (State)
Lago Texcoco/Tula	Cía de Las Fab de Papel San Rafael	125 000	110 000	San Rafael	Federal District
Lago Texcoco/Tula	Cía de Papel Loreto y Peña Pob	31 700	55 000	Tlalpán	Federal District
Lago Texcoco/Tula	Cía. Industrial de Ayotla	42 500	-	Ayotla	Mexico (State)
Lago Texcoco/Tula	Cía. Papelera El Fénix	-	12 000	Mexico City	Federal District
Lago Texcoco/Tula	Empaques de Cartón United	-	15 000	Colonia Maco	Distrito Federal
Lago Texcoco/Tula	Fábrica de Celulosa El Pilar	16 000	-	Ayotla	Mexico (State)
Lago Texcoco/Tula	Fábrica de Papel Coyoacán	2 000	14 500	México City	Federal District
Lago Texcoco/Tula	Fábrica de Papel La Soledad	-	4 000	Los Reyes	Mexico (State)
Lago Texcoco/Tula	Fábrica de Papel México	-	18 000	Ayotla	Mexico (State)
Lago Texcoco/Tula	Fábrica de Papel San Jose	-	3 000	La Paz	Mexico (State)
Lago Texcoco/Tula	Fábrica de Papel Santa Clara	-	8 500	Mexico City	Federal District
Lago Texcoco/Tula	La Florita	-	1 500	Colonia Panamérica	Mexico (State)
Lago Texcoco/Tula	Madruena y Cía.	-	2 500	Ixtapaluca	Mexico (State)
Lago Texcoco/Tula	Manufacturas de Papel Bidasua	-	5 000	Azcapotzalco	Federal District
Lago Texcoco/Tula	Moderakraft	-	25 000	Colonia Goaja	Mexico (State)
Lago Texcoco/Tula	Negociación Papelera Mexicana	2 100	18 000	Mexico City	Federal District
Lago Texcoco/Tula	Papelera Iruna	-	15 000	Ixtapalapa	Federal District
Lago Texcoco/Tula	Papelera Veracruzana	-	14 500	Azcapotzalco	Federal District
Lago Texcoco/Tula	Papelera de Texcoco	-	24 000	Cam. México-Texcoc	Mexico (State)
San Javier	Cía. Ind. de San Cristobal	60 000	65 000	Cam. México-Laredo	Mexico (State)
San Javier	Sonoco de México	-	12 000	Cam. México-Laredo	Mexico (State)
Santo Domingo	Fábrica de Papel Tuxtepec	58 100	50 000	Tuxtepec	Oaxaca
Tlalnepantla	Adamax	-	6 500	Tlalnepantla	Mexico (State)
Tlalnepantla	Empaques Modernos San Pablo	-	50 000	Tlalnepantla	Mexico (State)
Zavapán	Celulosa de Fibras Mexicanas	3 600	-	Apizaco	Tlaxcala
	Total - Hydrographic system :	385 240	714 500		

Source: ECLAC, on the basis of official data.

Table 5.7

GULF OF MEXICO HYDROGRAPHIC SYSTEM: NON-FERROUS METALS INDUSTRIES

River or body of water	Type of industry	Name of industry	Output (tons)	Locality	Administrative division
(Mexico)					
Jamapa	Aluminium plant	Aluminio S.A.de C.V.	45 000	Veracruz	Veracruz
Lago Texcoco/Tula	Copper refinery	Cobre de México SA de C.V.	75 300	Azcapotzalco	Federal District
		Total - Hydrographic system :	120 300		

Source: American Bureau of Metal Statistics Inc. (ABMS), Non Ferrous Metal Data 1983, New Jersey, Port City Press, Inc., 1984.

Table 5.8

GULF OF MEXICO HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

River or body of water	City	Population 1950	1960	1970	1980	Administrative division
(México)						
Actopán	Jalapa de Enríquez	51 166	78 120	127 081	201 473	Veracruz
Jamapa	Veracruz	101 220	153 705	242 351	306 843	Veracruz
Lago Texcoco/Tula	Mexico City	2 334 795	2 832 133	3 025 564	14 750 182	Federal District
Pánuco	Tampico	94 342	124 894	196 147	389 940	Tamaulipas
Purificación	Poza Rica de Hidalgo	1 863	71 770	121 341	198 003	Tamaulipas

Source: James W. Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin American Center Publications, University of California, 1981, and ECLAC, on the basis of official figures.

Table 5.9

GULF OF MEXICO HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Guatemala) a/							
Alta Verapaz	3 474	104 199	30.0	112 210	32.3	128 803	37.1
Baja Verapaz	3 124	96 485	30.9	106 975	34.2	115 602	37.0
Huehuetenango	7 403	288 088	38.9	368 567	49.8	431 343	58.3
Peten	14 342	10 625	0.7	25 646	1.8	52 771	3.7
Quiche	7 540	224 945	29.8	268 817	35.7	295 357	39.2
San Marcos	1 896	168 480	88.9	194 880	102.8	236 163	124.6
Totonicapán	690	92 152	133.6	108 426	157.2	132 872	192.7
Total - Guatemala :	38 468	984 973	20.5	1 185 520	24.5	1 392 912	29.4
(Mexico) a/							
Chiapas	73 887	1 210 870	16.4	1 569 053	21.2	2 084 717	28.2
Federal District	1 479	4 870 876	3 293.4	7 223 600	4 884.1	9 373 353	6 337.6
Guanajuato	30 589	1 735 490	56.7	2 270 370	74.2	3 006 110	98.3
Hidalgo	20 987	994 598	47.4	1 193 845	56.9	1 547 493	73.7
Mexico (State)	21 461	1 897 851	88.4	3 833 185	178.6	7 564 335	352.5
Nuevo León	16 139	269 712	16.7	423 672	26.3	632 761	39.2
Oaxaca	31 470	569 998	18.1	665 090	21.1	781 795	24.8
Puebla	33 919	1 973 837	58.2	2 508 226	73.9	3 347 685	98.7
Querétaro	11 769	355 045	30.2	485 523	41.3	739 605	62.8
San Luis Potosí	25 139	419 319	16.7	512 798	20.4	669 557	26.6
Tabasco	24 661	496 340	20.1	768 327	31.2	1 062 961	43.1
Tamaulipas	67 855	870 555	12.8	1 238 329	18.2	1 635 811	24.1
Tlaxcala	3 914	346 699	88.6	420 638	107.5	556 597	142.2
Veracruz	72 815	2 727 899	37.5	3 815 422	52.4	5 387 680	74.0
Total - Mexico :	436 084	18 739 088	35.9	26 928 079	51.1	38 390 461	72.2
Total - Hydrographic system :	474 552	19 724 062	34.3	28 113 599	48.3	39 783 373	67.8

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras, 1974. Situación demográfica: estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

Note: The figures appearing under the headings 1960, 1970 and 1980 actually correspond to the census dates given for each country.

a/ Dates of censuses: Guatemala: 18-04-64, 26-03-73, 26-03-81; Mexico: 08-06-60, 28-01-70, 04-06-80.

VI. NORTH PACIFIC HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The North Pacific hydrographic system covers an area of approximately 328 406 km^2 and is almost wholly within Mexican territory, except for the eastern bank of the Suchiate River, which is in Guatemalan territory. It encompasses the Mexican states of Jalisco, Aguascalientes, Colima, Michoacán, Guerrero and Morelos, and portions of the states of Nayarit, Durango, Guanajuato, Querétaro, México, Tlaxcala, Puebla, Oaxaca and Chiapas, as well as part of the department of San Marcos in Guatemala. To the north, it is bounded by the Mezquital or San Pedro River basin (which it does not include) and to the east, by the Sierra Madre Occidental. It generally runs in a NW-SE direction between 15° and 24° north latitude and 93° and 105°30' west longitude. The largest rivers which cross it from east to west are the Grande de Santiago and the Balsas rivers. Most of the other rivers are short in length, particularly those to the south of the Gulf of Tehuantepec. This hydrographic system also includes two large bodies of water: Lake Cuitzeo and Lake Chapala in Mexico (see map 6.1).

2. Climate

a) Climate types (Köppen classification): The North Pacific hydrographic system is entirely within the intertropical convergence zone (ICZ), where three types of synoptic phenomena are observed:

i) The formation of a front between cold air masses from the north and warm air masses from the south. This phenomenon occurs frequently in the winter;

ii) The Mexican front of air masses from the two oceans, which meet over the Sierra Madre Occidental and the Sierra Madre del Sur; and

iii) The formation of low-pressure which are produced by the tropical cyclones that are generated in areas of the Pacific and which affect southern and western Mexico.

This synoptic situation in southwestern Mexico, in combination with such factors of latitude and altitude, gives rise to a rainy tropical climate, with the rainfall occurring in the summer (Aw) throughout the coastal and inland zones of less than 1 000 metres in altitude. Inland and in coastal areas over 1 000 metres above sea level, the climate is rainy and temperate, with rainfall in the summer (Cw). A dry steppe climate (BS) is present in a small zone in the Sierra Madre del Sur to the west of the city of Oaxaca and in the depression of Lake Chapala (see map 6.2).

b) Precipitation: The area covered by the North Pacific hydrographic system can be divided into three well-defined and internally-consistent zones in terms of the meteorological phenomena which produce precipitation.

In the first zone, which is formed by the mountainous area along the border between this system and the Southern Endorheic hydrographic system, precipitation ranges from 250 to 750 mm annually and is mainly produced by convectional and orographic effects. Subtropical systems often cause precipitation in the winter. In the summer, rainfall is caused by tropical waves, lines of confluence of air masses and tropical cyclonic disturbances.

The second zone takes in almost the entire hydrographic system, except for the relatively small area of the first zone and three sectors (two on the coast and one inland area) which correspond to the third zone. In the second zone, precipitation varies between 700 and 1 000 mm annually in inland areas and between 1 000 and 2 000 mm annually in the lower-lying areas near the Pacific coast. During the summer, lines of confluence, tropical waves and tropical cyclones are the sources of rainfall.

The third zone is composed of the coastal areas of the states of Nayarit, Jalisco, Colima and Michoacán; part of the southern portion of the State of Chiapas and a part of the upper Balsas River basin. Heavy rainfall occurs in this zone (from 1 000 to 2 000 mm, and up to more than 3 000 mm in Chiapas). Precipitation is scant during the winter and its main sources in the summer are the tropical cyclonic disturbances originating over the Pacific Ocean (see map 6.3 and table 6.1).

c) Temperature: Latitude is the chief determinant of temperatures in those portions of the North Pacific hydrographic system which are less than 1 000 metres above sea level. The entire system is located to the south of the Tropic of Cancer and is therefore within a zone characterized by mean monthly temperatures over 18°C in areas of less than 1 000 metres in altitude. To the south of 21° north latitude, the annual isotherm

is over 25°C in the areas below 1 000 metres, i.e., the whole of the coast and the Balsas River basin. Above 1 000 metres, the annual isotherms decline to less than 15°C in the inland areas and the greatest annual temperature variation is 10°C at the highest altitudes. The harshest climate in terms of the lowest temperatures and greatest temperatures variations in the whole of the hydrographic system is found in the extreme north of the system and in the inland areas (the states of Zacatecas, Aguascalientes, Guanajuato, Querétaro, Mexico, etc.), while the most stable zones in terms of temperatures are the coastal areas and those closest to the Equator.

3. Geomorphology and soils

The four major physiographic units in this system are the Sierra Madre Occidental, the Sierra Volcánica Transversal, the Sierra Madre del Sur and the Balsas River valley.

The Sierra Madre Occidental is the continuation of the Endicott Mountains in Alaska and of the Rocky Mountains in Canada and the United States. Almost all of this physiographic unit is covered by andesitic rock and, in some places, by volcanic rocks, although there are small stretches of ancient intrusive igneous rock as well. Its average altitude is 2 200 metres and its highest peaks reach up to 3 000 metres above sea level.

The Sierra Volcánica Transversal rises on the southern edge of the Mexican high plateau along the 19th parallel north between the states of Puebla and Jalisco. The entire zone exhibits tectonic activity due to the presence of an E-W chain of volcanoes. Pyroclastic material made up of volcanic ash and sand covers part of the nearby plateaus, but basaltic rock predominates throughout the region.

In the Sierra Madre del Sur, which cuts across the states of Colima, Michoacán, Guerrero and Oaxaca, a great deal of intrusive igneous rock in the form of batholiths and Mesozoic sediments is observed. This mountainous area is actively tectonic and is a seismic zone. It is joined by small coastal plains in most areas, but in some cases the mountain slopes continue along the floor of the Pacific Ocean. Due to climatic factors the ancient plateaus composed of fill in Oaxaca and in the Mixteca Mountains are subject to denudation.

The Balsas River valley is a continuation of the great depression forming the Gulf of California and the plains of Sonora, Sinaloa and Nayarit, where ancient igneous rock and Mesozoic sediment abound. As a consequence of the folding which has occurred in recent geological periods, the Balsas depression is partly covered by tuff and lava flows that have emerged through the cracks and faults in this area. In the lower-lying areas deposits

and sediments are found that have been carried there as a result of the denudation of the nearby mountains, especially the Sierra Volcánica Transversal.

The predominant soil types in the system are (see map 6.4):

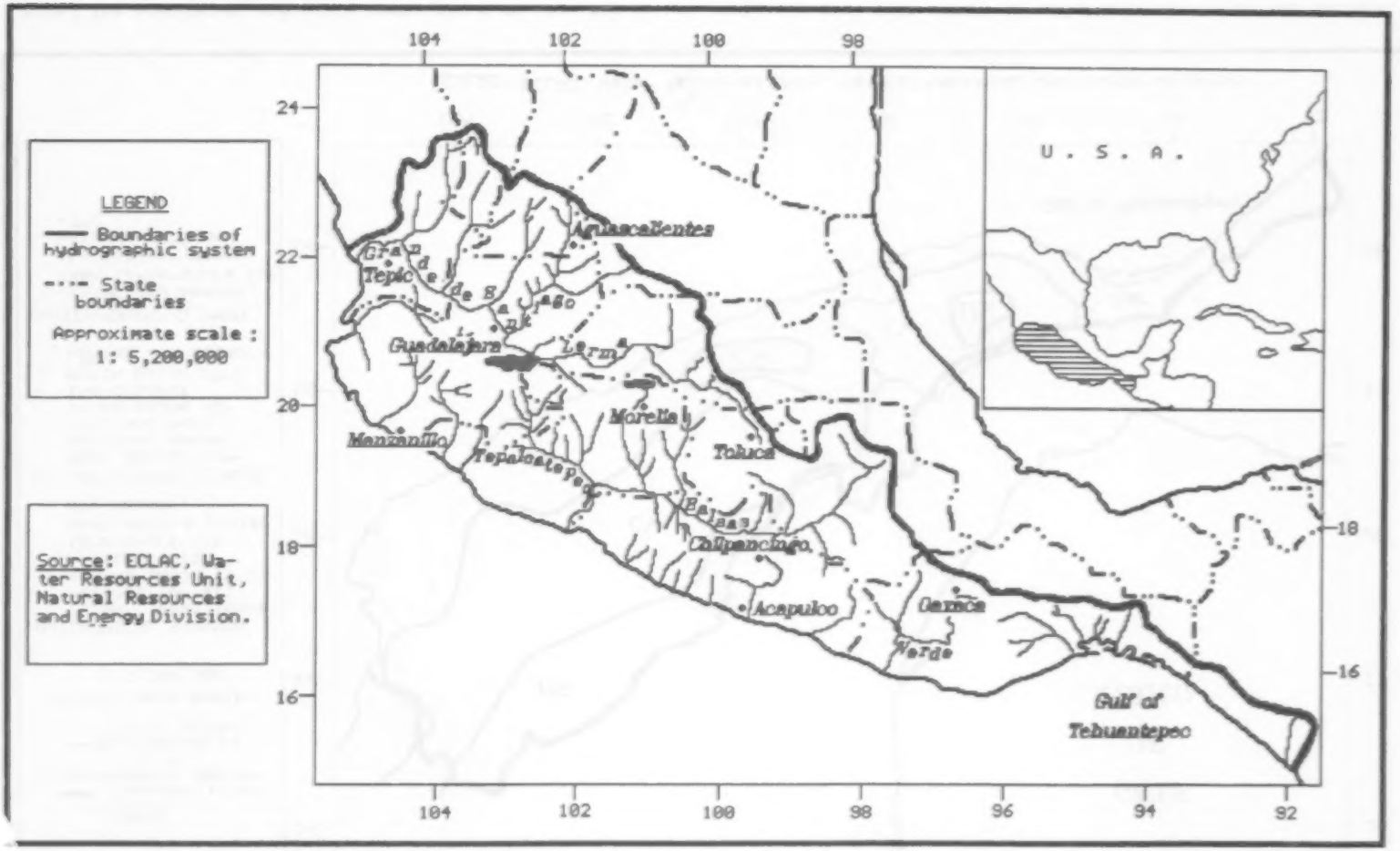
i) Luvisol and cambisol soils originating from low-intensity weathering are present in areas having temperate rainy climates (Cw). These soils are found on the western slope of the Sierra Madre Occidental, in the Sierra Volcánica Transversal, the Sierra Madre del Sur and the central plateaus of Oaxaca.

ii) Andosol soils deriving from intense weathering are observed in areas having temperate rainy climates (Cw). These soils are present from the State of Jalisco to the State of Puble and in all the Balsas depression and the upper Santiago River basin (extreme north-east of the State of Jalisco).

iii) Kastanozem soils associated with litosols and regosols originating from very low-intensity weathering in the zone with a steppe climate (BS). Within this hydrographic system, they are found in the steppes along the boundary between this system and the Southern Endorheic hydrographic system.

iv) The vertisols, rendzinas, phaeozems, gleysols and planosols are produced by intense weathering and are associated with rainy tropical climates (type Aw) or rainy temperate climates (Cw). They are located in the coastal plains of the whole hydrographic system. In general, they suffer from drainage problems (particularly the last two) due to the existence of clay horizons in the subsoil and the lack of gradient.

Map 6.1



Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

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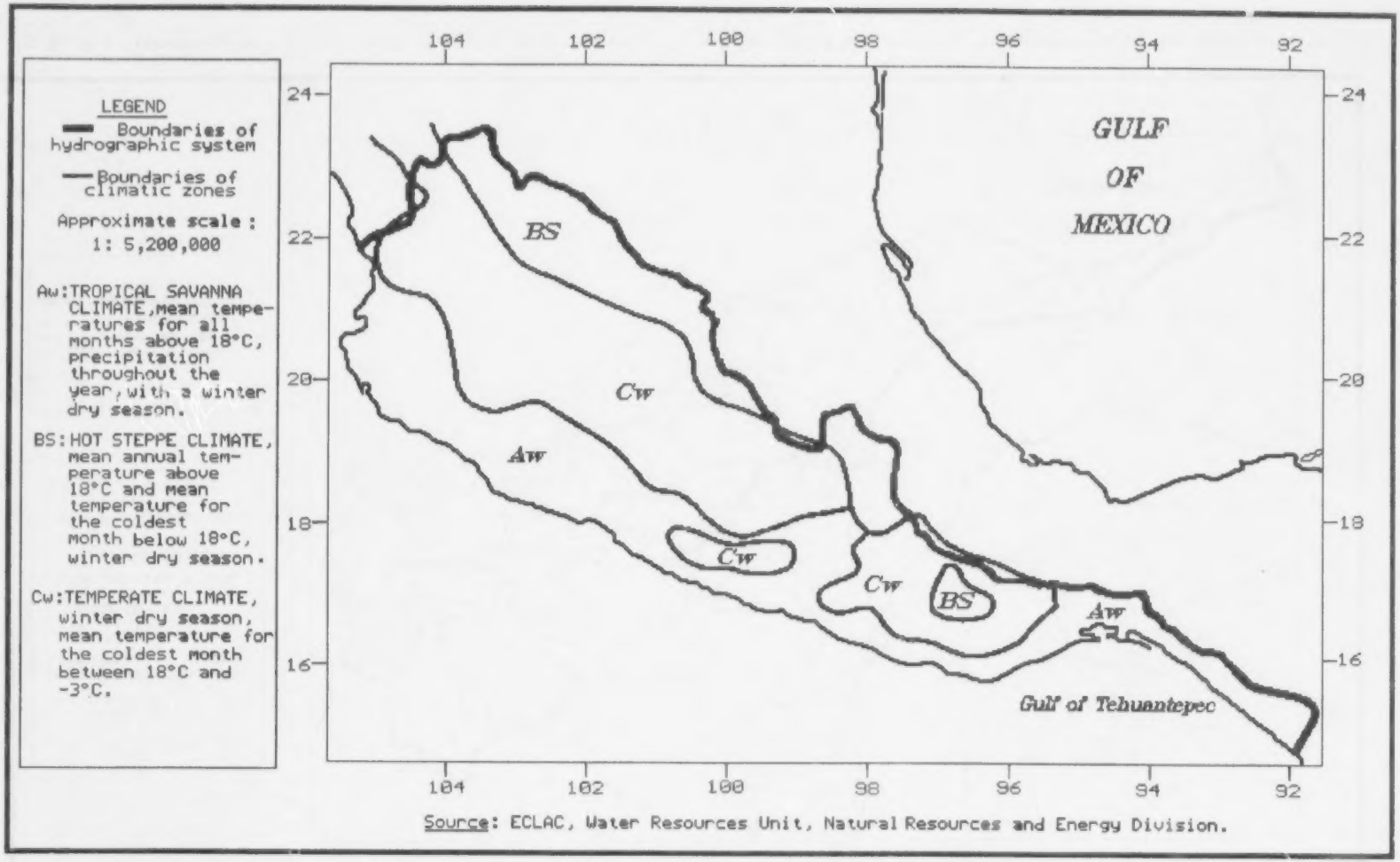
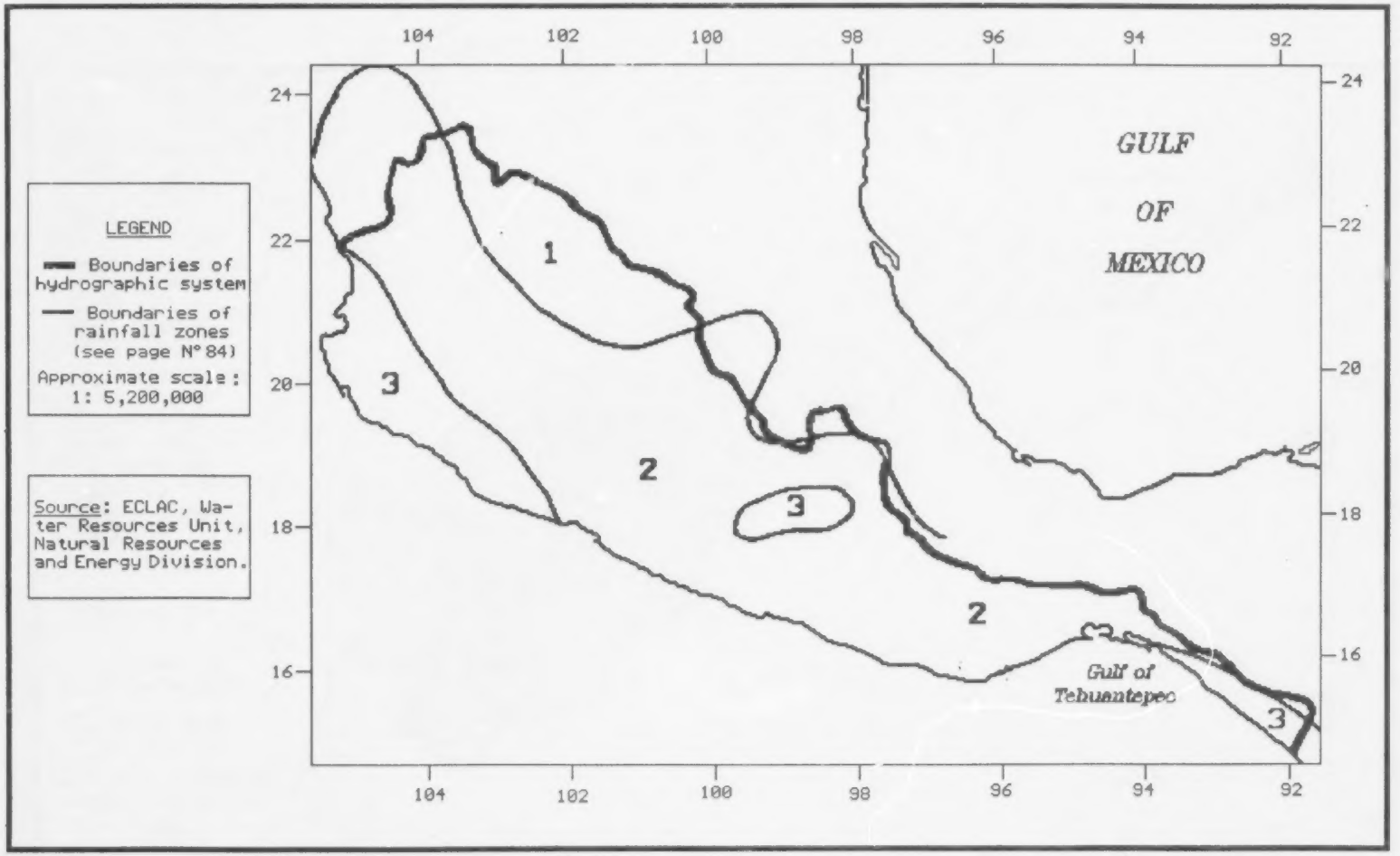


Source: ECLAC, Water Resources Unit, Natural Resources and Energy Division.

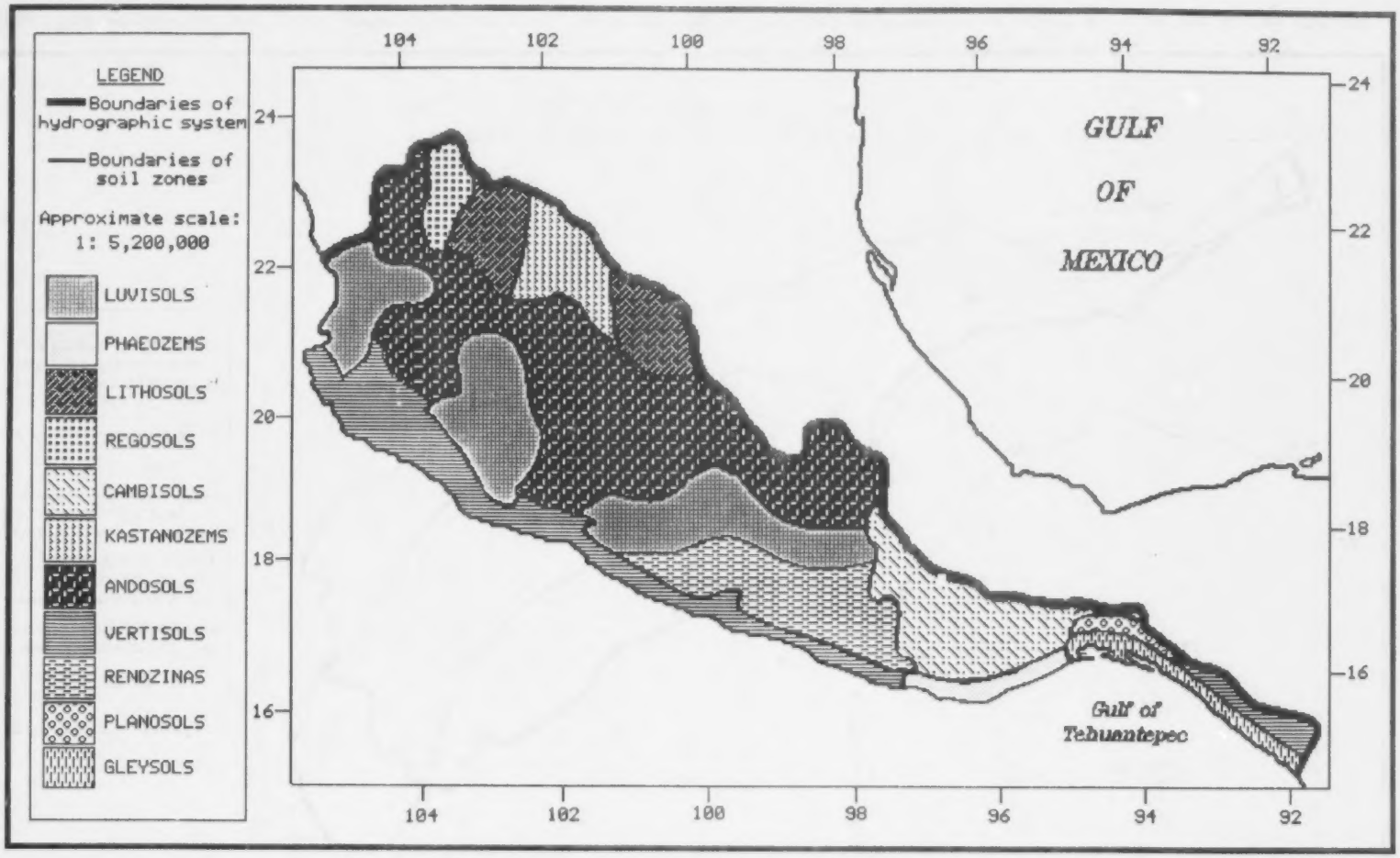
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 6.3



Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 6.4



Source: ECLAC, Water Resources Unit, Natural Resources and Energy Division.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 6.1

NORTH PACIFIC HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 6.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
AGUASCALIENTES, Mexico (30)												
21°53′N-102°18′W												
Altitude: 1 908 m												
mmp (map: 537 mm)	16	8	6	16	13	98	107	108	94	40	11	20
mmt (mat: 18.4°C)	13.8	15.4	17.9	20.7	22.5	21.9	20.6	20.5	19.7	18.1	15.9	14.0
Climate: BS												
OAXACA, Mexico (58)												
17°04′N-96°43′W												
Altitude: 1 550 m												
mmp (map: 634 mm)	3	3	10	28	72	135	89	97	137	47	9	4
mmt (mat: 20.7°C)	18.3	19.7	21.9	23.3	23.3	21.9	21.1	21.3	20.7	20.0	19.1	18.3
Climate: BS												
CHILPANCINGO, Mexico (30)												
17°33′N-99°30′W												
Altitude: 1 360 m												
mmt (map: 649 mm)	6	2	2	6	45	104	149	117	146	51	19	2
mmt (mat: 21.4°C)	19.9	20.5	21.8	22.8	23.3	22.2	21.5	21.5	21.2	21.4	20.8	19.9
Climate: Cw												
TOLUCA, Mexico (30)												
19°18′N-99°40′W												
Altitude: 2 680 m												
mmp (map: 773 mm)	9	4	11	27	66	140	150	154	119	61	23	9
mmt (mat: 12.7°C)	10.0	11.4	13.2	14.5	14.8	14.3	13.3	13.3	13.2	12.6	11.4	10.4
Climate: Cwk												
MORELIA, Mexico (30)												
19°42′N-101°11′W												
Altitude: 1 941 m												
mmp (map: 805 mm)	22	7	5	23	48	144	179	166	126	59	15	11
mmt (mat: 17.8°C)	14.4	16.1	18.3	20.1	20.9	20.0	18.7	18.6	18.4	17.5	16.0	14.7
Climate: Cw												
GUADALAJARA, Mexico (30)												
20°40′N-103°23′W												
Altitude: 1 589 m												
mmp (map: 931 mm)	13	6	8	8	26	143	267	209	152	69	13	17
mmt (mat: 19.2°C)	15.2	16.9	19.1	21.5	23.2	22.3	20.5	20.5	20.1	19.0	17.2	15.5
Climate: Cw												

READEX FICHE

Table 6.1 (concl.)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
MANZANILLO, Mexico (30)												
19°03'N-104°17'W												
Altitude: 8 m												
mmp (map: 1 002 mm)	30	9	6	9	12	119	151	206	283	139	22	16
mmt (mat: 26.5°C)	24.8	24.7	24.3	24.8	26.6	28.2	28.6	28.5	28.0	27.9	26.8	25.3
Climate: Aw												
TEPIC, Mexico (30)												
21°31'N-104°54'W												
Altitude: 915 m												
mmp (map: 1 349 mm)	20	12	14	19	10	176	379	329	239	110	14	27
mmt (mat: 20.7°C)	17.0	17.5	18.3	20.1	21.9	23.3	23.3	23.3	23.2	22.5	19.9	18.0
Climate: Cw												
ACAPULCO, Mexico (30)												
16°50'N-99°56'W												
Altitude: 28 m												
mmp (map: 1 430 mm)	11	1	1	4	35	274	236	230	426	165	35	12
mmt (mat: 27.8°C)	26.5	26.6	26.8	27.4	28.7	28.7	28.8	29.0	28.2	28.3	27.8	26.9
Climate: Aw												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

b/ The meanings of the abbreviations used in this column are:
- Aw: tropical savanna climate, dry season in winter
- Bs: steppe climate
- Cw: temperate climate, periodic precipitation, dry season in winter
- Cwk: temperate climate, dry season in winter, mean annual temperature below 18°C (due to altitude)
- map: mean annual precipitation
- mmp: mean monthly precipitation
- mat: mean annual temperature
- mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication, information was not available on non-ferrous metals industries in this hydrographic system.

Table 6.2

DAMS IN THE NORTH PACIFIC HYDROGRAPHIC SYSTEM

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
...	Agua Zarca	1981	1 500	I	Jalisco
Acatic	Lagunillas	1968	12 000	I	Jalisco
Achichilco	Cuquio	1967	7 500	I	Jalisco
Aculco	La Loma	1875	3 000	I	Mexico (State)
Agostitlán	Agostitlán	1955	14 300	I	Michoacán
Aguas del Obispo	Peñas de León	1965	2 200	I	Jalisco
Ajuchitlán	Andrés Figueroa	1983	102 500	I,C	Guerrero
Alcaparrosa	Alcaparrosa	1976	5 000	I	Jalisco
Alfaro	Alfaro	1980	700	C	Guanajuato
Angulo	Melchor Ocampo	1972	185 000	I	Michoacán
Armería	Corralitos	1969	1 020	I	Colima
Arroyo La Mina	Chichicapan	1969	3 000	I	Oaxaca
Arroyo Los Caños	San Jerónimo	1915	1 000	I	Aguascalientes
Arroyo La Mina	Chichicapan	1969	3 000	I	Oaxaca
Atopula	Huitzuco	1961	1 810	I	Guerrero
Atoyac	Manuel Avila Camacho	1946	424 000	I	Puebla
Atoyac	La Joya	1982	20 000	I	Jalisco
Ayuquila	Tacotán	1958	150 000	I,C	Jalisco
Azul	Colotlipa	1956	1 000	H	Guerrero
Balsas	El Infiernillo	1963	9 340 000	H	Michoacán
Balsas	Jose María Morelos	1968	710 000	I,H	Guerrero
Balsas	Carlos Ramírez U.	1985	782 000	H	Guerrero
Barranca de Soledad	Cardenas	1970	3 200	I	Tlaxcala
Belen	Belen	1874	-	...	Guanajuato
Blanco	50 Años de Irrigación en Mexico	1977	4 000	I	Aguascalientes
Boqueroncitos	Boqueroncitos	1978	5 000	I	Puebla
Borunda	Borunda	1900	600	I	Aguascalientes
Bravo	La Trinidad	1979	1 500	I	Mexico (State)
Cachihui	Tercer Mundo	1977	20 000	I	Michoacán
Cachivi	Fresno Laguna	1946	14 200	I	Michoacán
Cachivi	Chincua	1951	5 000	I	Michoacán
Calderón	La Red	1967	14 250	I	Jalisco
Calvillo	Media Luna	1976	15 000	I	Aguascalientes
Canal Valsequillo	Cacaloapan	1948	20 000	...	Puebla
Cerro Blanco	Cerro Blanco	1922	700	I	Aguascalientes
Changuitiro	Albino García	1971	2 000	I	Michoacán

Table 6.2 (cont. 1)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
Chichilco	Cuacuala	1980	6 500	I	Jalisco
Citala	La Yerbabuena	1970	6 000	I	Jalisco
Colorines	Colorines	1944	2 000	H	México (State)
Cuilapa	San Juan Catalán B.	1976	2 500	I	Guerrero
Cupatitzio	Cupatitzio	1962	5 300	H	Michoacán
Cutzamala	El Gallo	1985	530 000	I	Guerrero
De Cueva	Juan B.Morales	1972	1 000	I	Guanajuato
De La Arena	Corrales	1972	1 500	I	Michoacán
De La Erre	Peñuelitas	1960	24 000	I	Guanajuato
Del Monte	Las Torres	1976	2 000	S	Guanajuato
Del Oro	La Calera	1962	66 000	I	Guerrero
Duarte	Duarte	1982	3 500	C,I	Guanajuato
El Cedazo	El Cedazo	1960	1 000	I	Aguascalientes
El Chiquihuite	Charco Prieto	1960	970	I	Aguascalientes
El Jihuite	El Jihuite	1964	5 000	S	Jalisco
El Lirio	Natillas	1982	1 100	I	Aguascalientes
El Marijo	El Marijo	1974	3 000	I	Jalisco
El Morrillo	Achimec	1970	9 000	I	Jalisco
El Muerto	San Juan de Llanos	1975	9 000	I	Guanajuato
El Pastor	San Jerónimo	1981	750	I	Aguascalientes
El Pejo	El Pejo	1964	7 400	I	Michoacán
El Pochote	El Pochote	1977	7 000	I	Jalisco
El Salto	El Salto	1981	700	C	Guanajuato
El Saucillo	Valentín Gomez F.	1972	4 200	I	Jalisco
El Zapote	El Zapote	1977	3 000	I	Querétaro
Encarnación	Valerio	1945	12 000	I	Jalisco
Escurrimientos	Torre Blanca	1850	1 200	I	Michoacán
Gambuita	Gambuita	1960	1 500	I	Guanajuato
Grande	Piedra Azul	1968	870	I	Oaxaca
Grande de Huitzo	Los Cuajilotes	1970	3 000	I	Oaxaca
Grande de Morelia	Cointzio	1939	84 000	I,C,H	Michoacán
Guanajuato	La Purísima	1980	110 000	I,C	Guanajuato
Huajuapan	Yosocuta	1969	46 800	I	Oaxaca
Huenchillos	Barranca de Los Portales	1965	200	I	Aguascalientes
Huitchila	Gral.Fco.Leyva S.	1975	1 000	I	Morelos
Ixcotlán	El Sol y La Luna	1961	1 819	I	Tlaxcala
Ixtlahuacán	Los Sauces	1981	11 500	I	Jalisco
Jalpán	Jalpán	1977	8 000	I	Querétaro
Jalpilla	Jalpa	1976	6 000	I	Guanajuato
Jaripo	Jaripo	1950	10 100	I	Michoacán
Jocuixtle	El Banadero	1970	8 000	I	Nayarit
Juache	La Laborcita	1982	310	R,C	Guanajuato
Juiquinaque	Juiquinaque	1976	7 000	I	Jalisco
La Arena	Santa Catarina	1966	9 600	I	Querétaro
La Cantera	La Cantera	1967	1 200	I	Jalisco
La Cantera	El Techalote	1970	1 400	I	Tlaxcala
La Cofradía	La Cofradía	1970	8 000	I	Michoacán

Table 6.2 (cont. 2)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
La Cuna	La Cuna	1976	5 000	I	Jalisco
La Expiración	El Encino	1969	1 800	I	Oaxaca
La Gavia	Dolores(La Gavia)	1962	3 800	I	Mexico (State)
La Gavia	Ignacio Ramírez	1966	26 300	I,C	Mexico (State)
La Joya	La Joya	1958	5 000	I	Jalisco
La Labor	La Codorniz	1966	5 400	I	Aguascalientes
La Laja	Ignacio Allende	1968	251 000	I,C	Guanajuato
La Llave	La Gavia	1980	150 580	C	Guanajuato
La Parada	Santa Genoveva	1949	4 000	I	San Luis Potosí
La Patina y Castillos	El Palote	1954	10 000	C,S	Guanajuato
La Providencia	La Concha	1960	1 700	I	Jalisco
La Providencia	La Providencia	1970	1 550	I	Michoacán
La Quemada	La Quemada II	1941	1 090	I,C	Jalisco
La Sauceda	La Sauceda	1980	16 000	I	Jalisco
La Tejada	El Cuervo	1956	4 400	I	Jalisco
La Tinaja	La Tinaja	1948	2 475	I	Jalisco
La Tinaja	La Tinaja	1975	1 000	I	Jalisco
La Venta	San Franco	1898	3 000	I,C	Guanajuato
La Victoria	La Victoria	1958	550	I	Mexico (State)
La Yerbabuena	Yerbabuena	1970	3 200	I	Michoacán
Lagos	Cuarenta	1949	30 000	I	Jalisco
Las Alazanas	Las Alazanas	1967	5 200	I	Michoacán
Las Compuertas	San Jose Joya del Calvillo	1966	1 010	I	Guanajuato
Las Nutrias	De Gonzalo	1953	10 000	I	Michoacán
Las Tortugas	Huastla	1949	5 000	I	Jalisco
Lentejilla	Ciénaga de Galvanes	1978	10 000	I	Guanajuato
Lerma	Tepuxtepec	1935	358 000	H	Michoacán
Lerma	Solis	1949	850 000	I,C	Guanajuato
Lerma	Jose Antonio Alzate	1962	35 300	I	Mexico (State)
Lerma	El Potrerito	1969	1 400	I	Guanajuato
Loa Alamitos	Los Alamitos	1954	700	I	Aguascalientes
Los Campos	Pilotes	1916	830	I	Aguascalientes
Los Castillos	Los Castillos	1977	1 500	C	Guanajuato
Los Fresnos	Los Fresnos	1957	6 000	I	Michoacán
Los Ocotes	San Antonio de Aceves	1970	21 000	I,C	Guanajuato
Los Otates	Los Olivos	1961	20 000	I	Michoacán
Los Sabinos	Santa Cruz de La Soledad	1969	1 200	I	Jalisco
Malacatepec	Villa Victoria	1944	210 000	H	Mexico (State)
Malacatepec	Tilostoc	1952	14 000	H	Mexico (State)
Malpaso	Malpaso	1865	4 000	I	Zacatecas
Mascota	Corrinchis	1977	20 000	I	Jalisco
Mazatepec	Hurtado	1879	22 000	I	Jalisco
Mesillas	Mesillas	1952	1 000	I	Aguascalientes
Mexquitic	Alvaro Obregón	1926	4 980	I	San Luis de Potosí
Mexticacán	Mexticacán	1952	1 350	I	Jalisco
Mezquitillos	Ordena Vieja	1970	4 000	I	Aguascalientes
Mitepec	Huachinantla	1978	5 000	I	Puebla

Table 6.2 (cont. 3)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
Morcinique	Abelardo Rodríguez	1930	28 000	I	Aguascalientes
Moreno de Bravo	Moreno de Bravo	1977	2 500	I	Michoacán
Negro	Río Negro	1972	530	I	Oaxaca
Neutla	Ing.Isidro Orozco	1975	5 000	I	Guanajuato
Nexpa	El Guineo	1985	131 433	I,C	Guerrero
Ojo de Agua	Ojo de Agua de Los Reyes	1983	283	C	Guanajuato
Otates	San Juan de Otates	1983	2 278	I,C	Guanajuato
Pabellón	Pabellón	1931	-	I	Aguascalientes
Papagayo	Ambrosio Figueroa	1964	32 000	H	Guerrero
Partidas	Partidas	1958	2 600	I	Jalisco
Penjamillo	El Capulin	1961	24 000	I	Michoacán
Pénjamo	La Golondrina	1968	6 000	I,C	Guanajuato
Peñita	San Rafael	1975	3 000	I	Querétaro
Piedras Azules	Nicolas Bravo	1971	750	I	Guanajuato
Pinzanes	Los Pinzanes	1957	4 350	H	México (State)
Poliutla	Vicente Guerrero	1968	250 000	I	Guerrero
Pucuato	Pucuato	1946	11 300	I	Michoacán
Quiringuicharo	La Noria	1948	3 500	I	Michoacán
Quitupan	Vicente G.Villaseñor	1950	19 000	I	Jalisco
Rosa Amarilla	Volantín	1943	12 500	I	Jalisco
Sabaneta o Aporo	Sabaneta	1948	3 441	I	Michoacán
Sahuayo	Las Fuentes	1949	2 100	I	Michoacán
San Francisco	Las Grullas	1959	1 320	I	Aguascalientes
San Ignacio	San Ignacio	1977	1 600	I	Jalisco
San Miguel	San Miguel El Alto	1948	2 200	I	Jalisco
San Miguel	Caballerías	1966	1 920	I	Michoacán
San Miguel	Basilio Badillo	1973	174 000	I	Jalisco
San Onofre	San Onofre	1982	2 000	I	Jalisco
San Pedro	El Niágara	1963	16 500	I	Aguascalientes
Santa Fe	Santa Fe del Río	1967	2 650	I	Michoacán
Santa Rosa	Ignacio L.Vallarta	1972	6 640	I	Jalisco
Santiago	Colimilla	1951	4 800	H	Jalisco
Santiago	Luis M.Rojas	1962	1 550	H	Jalisco
Santiago	Manuel M.Diéguez	1964	400 000	H	Jalisco
Santiago	Texcalama	1981	2 750	I	Jalisco
Santiago y Pabellón	Calles	1931	340 000	I	Aguascalientes
Santos o Tepozan	Peña Blanca	1959	4 500	I	Aguascalientes
Saucillo	Saucillo	1750	6 000	I	Aguascalientes
Silao	El Tigre	1982	1 210	C	Guanajuato
Tarecuato	Tarecuato	1939	1 200	I	Michoacán
Tehuantepec	Pdte.Benito Juárez	1961	942 000	I,C	Oaxaca
Tenasco	Tenasco	1962	10 500	I	Jalisco
Teocaltiche	San Antonio	1968	2 100	I	Jalisco
Teocuitatlán	Huejotitlán	1967	7 100	I	Jalisco
Tepecoacuilco	Valerio Trujano	1964	39 400	I	Guerrero
Tepehuaje	Ojo de Agua	1958	2 900	I	Jalisco
Teuchitlán	La Vega	1956	44 000	I	Jalisco

Table 6.2 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Mexico)					
Tlazazalca	Urepetiro	1964	12 800	I,C	Michoacán
Tomatlán	Cajón de Peña	1976	470 000	I,H,C	Jalisco
Topalpa	El Nogal	1976	19 000	I	Jalisco
Tranque Colotlán	La Soledad	1953	2 000	I	Jalisco
Tule	El Tule	1969	30 000	I	Jalisco
Tule	El Pajamán	1975	4 000	I	Jalisco
Tultenango o Tepetongo	Santa Teresa	1956	5 000	I	Michoacán
Tuxpán	La Purísima	1910	1 000	I	Michoacán
Tuxpán	Tuxpán	1957	20 000	H	Michoacán
Villa Guerrero	Villa Guerrero	1952	2 420	I	Jalisco
Villa Hidalgo	González Gallo	1963	2 520	I	Jalisco
Viramontes	Topiltepec	1982	2 200	I	Guerrero
Yahualica	El Estribón	1947	6 500	I	Jalisco
Zicuirán	Zicuirán	1957	50 000	I	Michoacán
Zinapecuaro	Antonio Rodríguez Langone	1964	7 500	I	Michoacán
Zitacuaro	El Bosque	1954	220 000	H	Michoacán
	Total - Hydrographic system:		18 471 559		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Dams for which no reservoir capacity is given are lateral dams.

b/ Symbols used in "Purpose" column:
C: Flood control
H: Hydroelectricity
I: Irrigation
R: Recreational purposes
S: Water supply

Table 6.3

NORTH PACIFIC HYDROGRAPHIC SYSTEM: HYDROELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Mexico)				
Atoyac o Verde	Temascal	154.0	Oaxaca	San Miguel
Balsas	La Villita	300.0	Michoacán	Melchor Ocampo
Cupatitzio	Cupatitzio	72.0	Michoacán	Uruapán
Cupatitzio	El Cobano	52.0	Michoacán	Gabriel Zamora
Grande de Santiago	Manuel M Diéguez	62.0	Jalisco	Amatitán
Grande de Santiago	Puerto Grande	23.0	Jalisco	Tonalá
La Unión	Infiernillo	1 012.0	Guerrero	La Unión
Lerma	Lerma	80.0	Michoacán	Contepec
Papagayo	Ambrosio Figueroa	30.0	Guerrero	La Venta
Salado	Colinilla	51.0	Jalisco	Colinilla
Suchiate	J. Cecilio del Valle	21.0	Chiapas	Metapa
Tilostoc	Ing N. M. De Mesa	25.0	Mexico (State)	Viuda de Allende
Tilostoc	Ixta Pantongo	106.0	Mexico (State)	Valle de Bravo
Tilostoc	Santa Bárbara	68.0	Mexico (State)	Nuevo Santo Tomás
Tilostoc	Timbangato	135.0	Mexico (State)	Otzohuapán
	Total - Hydrographic system:	2 191.0		

Source: ECLAC, on the basis of official data.

Table 6.4

NORTH PACIFIC HYDROGRAPHIC SYSTEM: THERMOELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Mexico)				
Lerma	Celaya	43.0	Guanajuato	Celaya
Lerma	Salamanca	322.0	Guanajuato	Salamanca
Santiago	Zapodán	87.0	Jalisco	Guadalajara
	Total - Hydrographic system:	452.0		

Source: ECLAC, on the basis of official data.

Table 6.5

NORTH PACIFIC HYDROGRAPHIC SYSTEM: OIL REFINERIES

River or body of water	Name of refinery	Barrels per day	Administrative division	Locality
(Mexico)				
Lerma	Salamanca	210 000	Guanajuato	Salamanca
Pacific Ocean	Salina Cruz	170 000	Oaxaca	Salina Cruz
	Total - Hydrographic system :	380 000		

Source: ECLAC, on the basis of data compiled by the Latin American Energy Organization (OLADE), 1979.

Table 6.6

NORTH PACIFIC HYDROGRAPHIC SYSTEM: IRON AND STEEL INDUSTRIES

River or body of water	Name of industry	Output (tons)	Administrative division	Locality
(Mexico)				
Atoyac	HYLSA de México	450 000	Puebla	San Miguel Xoxtla
Pacific Ocean	Sicartsa	1 300 000	Michoacán	Lázaro Cárdenas
	Total - Hydrographic system :	1 750 000		

Source: ECLAC, on the basis of data compiled by the Latin American Iron and Steel Institute (ILAFA), 1974.

Table 6.7

NORTH PACIFIC HYDROGRAPHIC SYSTEM: PAPER AND PULP INDUSTRIES

River	Name of industry	Output (tons/year)		Locality	Administrative division
		Pulp	Paper		
(Mexico)					
Apatlaco	Unipac	-	20 000	Cuernavaca	Morelos
Atoyac	Cía. Papelera Poblana	-	7 000	Puebla	Puebla
Atoyac	Fábrica de Papel San Juan	-	10 000	Texmelucán	Puebla
Atoyac	Papelera Mexicana	-	12 000	Puebla	Puebla
Lerma	Cartonera Sago	-	8 500	Atizapán	Mexico (State)
Lerma	Kimberley Claril de México	2 000	35 000	San Bartolo	Mexico (State)
Pesquería	Celulosa de Bajío	1 500	-	Salvatierra	Guanajuato
Santiago	La Paz	-	7 000	Guadalajara	Jalisco
Santiago	Papelera del Pacífico	-	8 000	Guadalajara	Jalisco
Tuxpán	Cía. Industrial de Atenquique	40 000	70 000	Atenquique	Jalisco
	Total - Hydrographic system :	43 500	177 500		

Source: ECLAC, on the basis of official data.

Table 6.8

NORTH PACIFIC HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

River or body of water	City	Population 1950	1960	1970	1980	Administrative division
(Mexico)						
Apatacio	Cuernavaca	30 597	85 620	159 909	241 337	Morelos
Atoyac	Puebla de Zaragoza	211 331	332 821	521 885	710 833	Puebla
Atoyac o Verde	Oaxaca	46 741	78 639	116 826	135 601	Oaxaca
Cupatitzio	Uruapán	31 409	61 221	104 475	147 030	Michoacán
Grande	Morelia	63 245	153 481	209 507	251 011	Michoacán
Huimilpán	Queretaro	49 209	103 907	140 379	185 821	Querétaro
Lerma	Salamanca	20 586	67 097	103 740	105 543	Guanajuato
Lerma	Toluca de Lerdo	52 968	156 033	220 195	241 920	Mexico (State)
Mololoa	Tepic	24 600	73 576	111 344	139 881	Nayarit
Pacific Ocean	Acapulco	27 913	84 720	234 866	462 144	Guerrero
Santiago	Guadalajara	317 016	740 394	1 196 218	2 467 657	Jalisco
Santiago	Zapopán	6 164	54 562	182 934	104 497	Jalisco
Turbio	Irapuato	49 443	127 174	175 966	161 047	Guanajuato
Turbio	León	122 566	260 633	453 976	624 816	Guanajuato
Verde Grande	Aguascalientes	93 363	154 211	222 105	257 179	Aguascalientes

Source: Jame W. Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin American Center Publications, University of California, 1981, and ECLAC, on the basis of official figures.

Table 6.9

NORTH PACIFIC HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960		1970		1980	
		Population	Density	Population	Density	Population	Density
(Guatemala) a/							
San Marcos	1 896	168 480	88.9	194 880	102.8	236 163	124.6
Total - Guatemala :	1 896	168 480	88.9	194 880	102.8	236 163	124.6
(Mexico) a/							
Aguascalientes	5 589	243 363	43.5	338 142	60.5	519 439	92.9
Colima	5 455	164 450	30.1	241 153	44.2	346 293	63.5
Guerrero	63 794	1 186 716	18.6	1 597 360	25.0	2 109 513	33.1
Jalisco	80 137	2 443 261	30.5	3 296 586	41.1	4 371 998	54.6
Michoacán	59 864	1 851 876	30.9	2 324 226	38.8	2 868 824	47.9
Morelos	4 941	386 264	78.2	616 119	124.7	947 089	191.7
Nayarit	16 573	233 957	14.1	326 419	19.7	435 672	26.3
Oaxaca	63 894	1 157 268	18.1	1 350 334	21.1	1 587 281	24.8
Zacatecas	26 264	286 241	10.9	333 012	12.7	397 891	15.1
Total - Mexico :	326 510	7 953 396	22.0	10 423 350	28.5	13 583 999	36.8
Total - Hydrographic system :	328 406	8 121 876	22.6	10 618 230	29.2	13 820 162	37.6

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras, 1974. Situación demográfica: estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

Note: The figures appearing under the headings 1960, 1970 and 1980 actually correspond to the census dates given for each country.

a/ Dates of censuses: Guatemala: 18-04-64, 26-03-73, 26-03-81; Mexico: 08-06-60, 28-01-70, 04-06-80.

VII. YUCATAN HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The Yucatán hydrographic system encompasses the entire Yucatán Peninsula, which is located in the southern extreme of Mexico. It takes in the states of Yucatán, Quintana Roo and Campeche and has an approximate area of 141 523 km^2 between approximately 17°45' and 21°30' north latitude and between 86°50' and 92°30' west longitude, and its boundaries are formed by the Gulf of Mexico to the west, by the Caribbean Sea to the north and east, and by Belize and Guatemala to the south (see map 7.1).

2. Climate

a) Climate types (Köppen classification): Tropical climates (type A) characterized by high temperatures throughout the year predominate in this hydrographic system, which is within the intertropical zone. The tropical climates found within the Yucatán Peninsula can be divided into various subtypes in terms of the annual distribution and total amounts of precipitation. These climates become wetter as one moves further south (see map 7.2).

b) Precipitation: The amount of precipitation grows progressively greater starting from the northern part of the peninsula and moving inland, and ranges from less than 600 mm annually along the coast north of the city of Mérida to 2 000 mm in the State of Tabasco (see map 7.3). In this latter area, precipitation is mainly due to convection, which reaches its peak in the summer. During this season, the thermal equator shifts to its northernmost position thereby entering the zone of the horse latitudes, where large masses of ascending hot and humid air produce prolonged and abundant rainfall. The moisture contained in these air masses from the Equator gradually decreases as they move over the continental land mass in a northerly direction, which is why annual precipitation is much lower in the northern portion of the peninsula (see table 7.1).

c) Temperature: One of the characteristics of tropical climates is an even pattern of high temperatures throughout the year; in the case of the Yucatán hydrographic system, mean temperatures exceed 25°C. Since this system is near the Tropic of Cancer, the mean monthly temperatures in summer and in winter differ by around 5°C, and the difference between minimum and maximum temperatures amounts to up to 30°C (8°C and 38°C, respectively) (see table 7.1).

3. Geomorphology and soils

The Yucatán hydrographic system is one of the five major morphological elements defining the territory of Mexico. In morphological terms, it is a natural appendage of the northern sedimentary platform of Guatemala, which is chiefly made up of horizontal layers of limestone; its mean altitude is 30 metres above sea level and its inland terraces are from 160 to 250 metres in altitude. The peninsula's formation is homogeneous and its relief is essentially the product of the action of groundwater (karstic type).

In the vast uplifted plain which forms the Yucatán peninsula, various types of soils are found. The soil types depends both on the climatic conditions of the zone and on the characteristics of the parent material (see map 7.4).

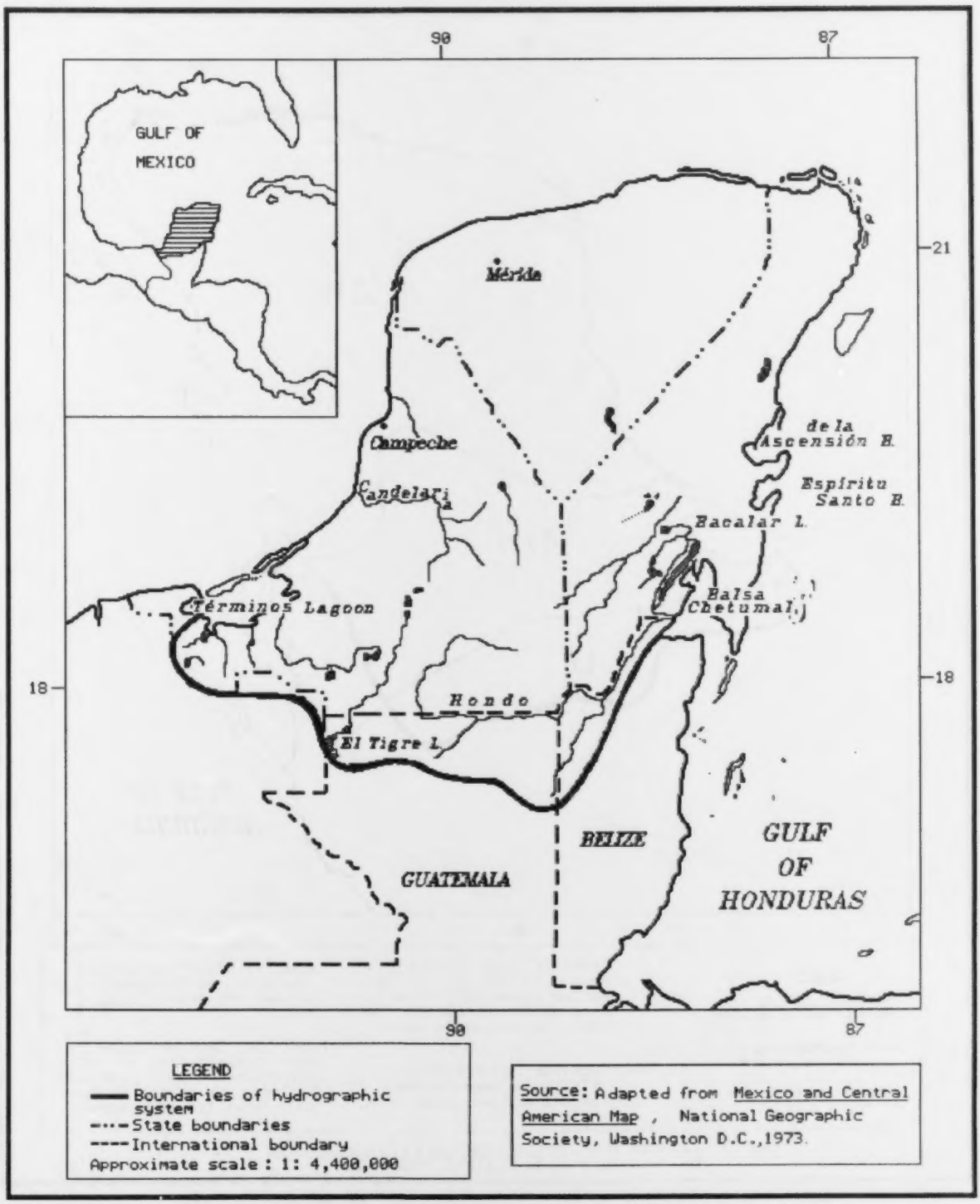
In the north of the peninsula, the soils develop under arid conditions, they have little depth and low fertility. The litosols are also stony and are formed from a coral limestone pavement with a hard crust. The coastal regosols have good drainage, but are susceptible to wind erosion and the accumulation of soluble salts. The rendzinas in this part of the peninsula form complex associations with litosols and outcrops of denuded rocks which, together with the lack of rainfall, make agriculture difficult.

The cambisols develop in conditions somewhat more humid from sedimentary calcareous rocks and suffer from problems of erosion, even in areas of gentle slopes, but are fertile when there is sufficient rainfall and the relief permits.

In the central and subhumid part of the peninsula, the luvisols have a low natural fertility and slow internal drainage which make their management difficult. The rendzinas in this more humid zone are fertile and well drained. This makes them satisfactory for traditional agriculture.

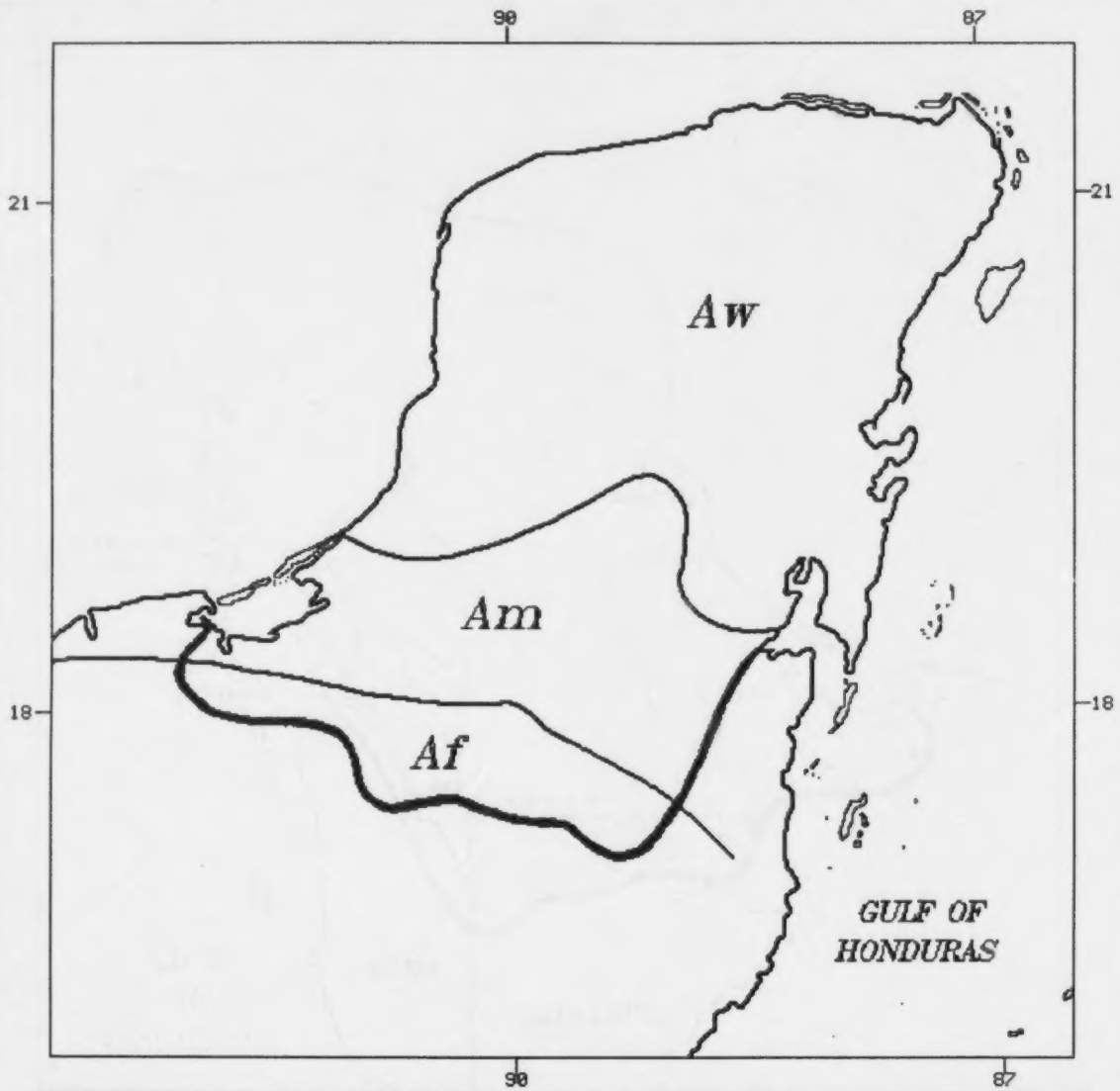
The soils of the extreme south and most humid part of the hydrographic system have one predominant characteristic which determines their potential for use: insufficient drainage and excess groundwater during the greater part of the year. In this situation are found vertisols, gleysols, planosols and fluvisols.

Map 7.1



Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 7.2



LEGEND

Boundaries of hydrographic system

Boundaries of climatic zones

Approximate scale : 1: 4,400,00

Af: TROPICAL JUNGLE CLIMATE, mean temperatures for all months above 18°C, precipitation throughout the year, countinuosly wet.

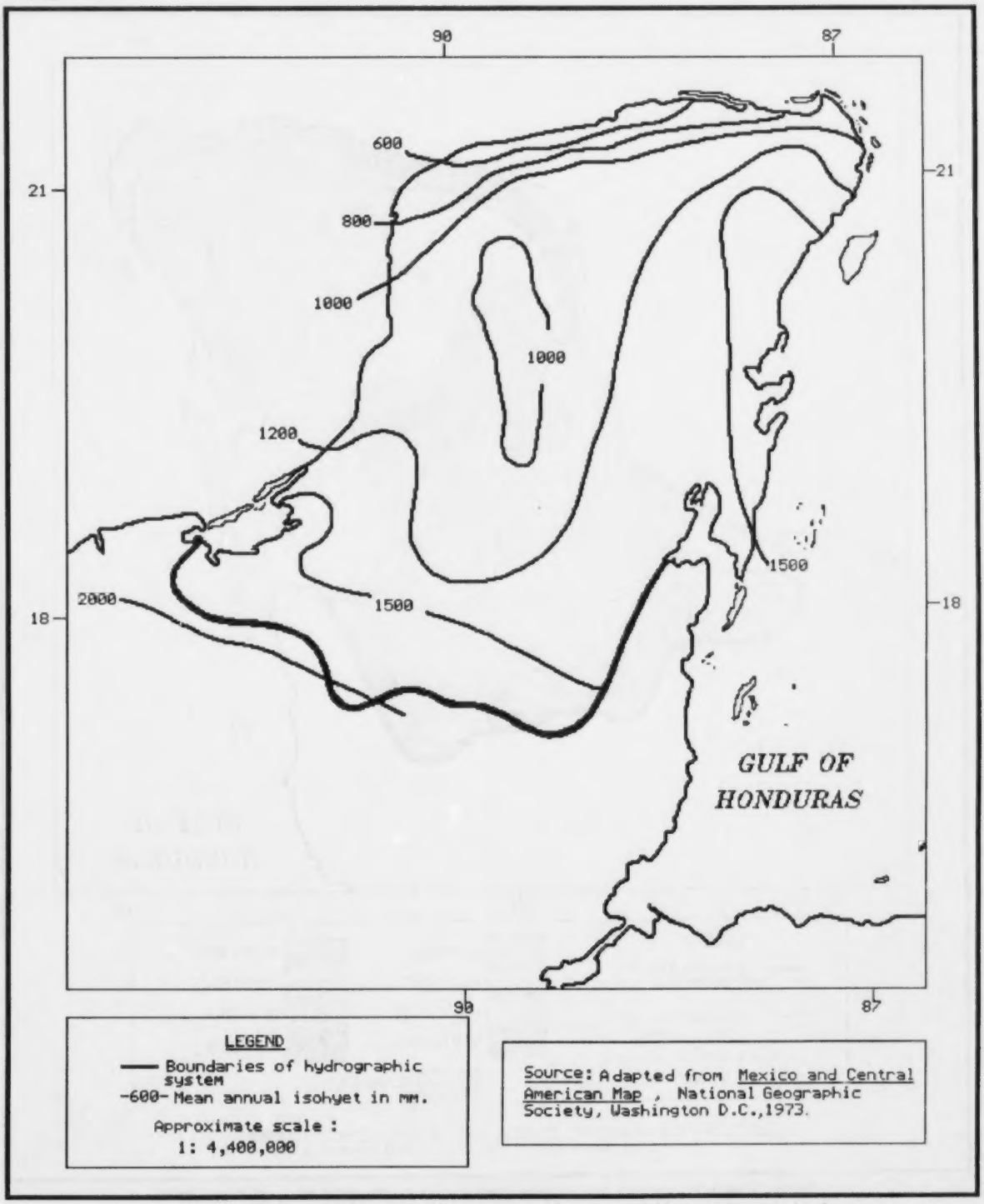
Am: TROPICAL RAINFOREST CLIMATE, mean temperatures for all months above 18°C, precipitation throughout the year, with a short winter dry season (one month).

Aw: TROPICAL SAVANNA CLIMATE, mean temperatures for all months above 18°C, precipitation throughout the year with a winter dry season.

Source: Adapted from Mexico and Central American Map , National Geographic Society, Washington D.C.,1973.

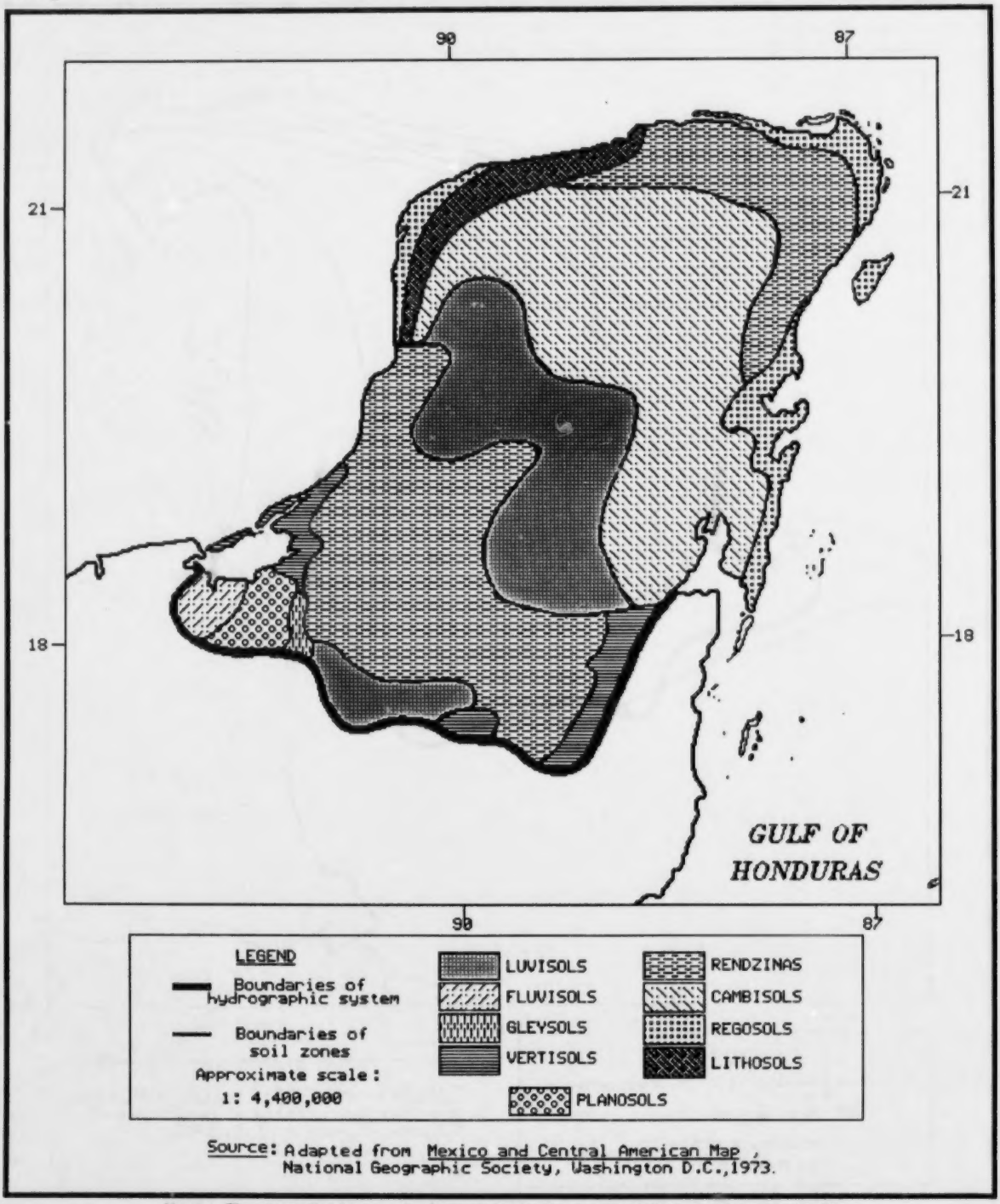
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 7.3



Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 7.4



Source: Adapted from Mexico and Central American Map, National Geographic Society, Washington D.C., 1973.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 7.1

YUCATAN HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 7.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
MERIDA, Mexico (77)												
20°58'S-89°38'W												
Altitude: 22 m												
mmp (map: 913 mm)	31	16	19	26	81	151	141	129	154	103	32	30
mmt (mat: 25.9°C)	22.9	223.8	25.4	27.1	28.0	27.7	27.4	27.4	27.2	26.1	24.0	23.4
Climate: Aw												
CAMPECHE, Mexico (30)												
19°51'N-90°33'W												
Altitude: 5 m												
mmp (map: 1 094 mm)	17	13	13	10	61	152	206	201	221	119	54	27
mmt (mat: 26.5°C)	23.5	24.3	26.1	27.8	28.5	28.7	28.0	28.0	27.7	26.7	24.8	23.6
Climate: Aw												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have beeen kept, in years.

b/ The meanings of the abbreviations used in this column are:
- Aw: tropical savanna climate, dry season in winter
- map: mean annual precipitation
- mmp: mean monthly precipitation
- mat: mean annual temperature
- mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication, information was not available on dams, hydroelectric plants, thermoelectric plants, oil refineries, iron and steel industries, paper and pulp industries or non-ferrous metals industries located in this hydrographic system.

Table 7.2

YUCATAN HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

Body of water	City	Population 1950	1960	1970	1980	Administrative division
(Mexico) Gulf of Mexico	Mérida	142 858	190 642	253 856	269 582	Yucatán

Source: James W. Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin America Center Publications, University of California, 1981, and ECLAC, on the basis of official figures.

Table 7.3

YUCATAN HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Mexico) a/							
Campeche	56 114	168 219	3.0	251 556	4.5	420 553	7.5
Quintana Roo	42 030	50 169	1.2	88 150	2.1	225 985	5.4
Yucatán	43 379	614 049	14.2	758 355	17.5	1 063 733	24.5
Total - Hydrographic system :	141 523	832 437	5.9	1 098 061	7.8	1 710 271	12.1

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras, 1974. Situación demográfica: estado y movimiento de la población, Washington D.C., OAS, General Secretariat, 1974, and national censuses.

a/ Dates of censuses: 08-06-60, 28-01-70, 04-06-80.

VIII. CARIBBEAN HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The Caribbean hydrographic system covers an estimated area of 646 213 km^2 and stretches from Colombia in the south up to Guatemala and Belize in the north. This system encompasses the Magdalena river basin in Colombia and the Atlantic slope of the Andes Mountains in Central America. The longest river subsystem (605 km) is that of the Coco or Segovia River on the border between Nicaragua and Honduras. Generally speaking, the streams emptying into the Caribbean Sea are short in length due to the relief of the land, except for the Magdalena River, which follows a broad and extensive course through an intermontane valley. The co-ordinates delimiting the Caribbean hydrographic system are 72° and 91° west longitude and 1° and 18° north latitude (see maps 8.1 and 8.2).

2. Climate

a) Climate types (Köppen classification): The two factors which determine the predominant climate types in the Caribbean hydrographic system are latitude and altitude. In zones below 1 500 metres above sea level, latitude is the determining factor in the presence of rainy tropical climates (type A). Above 1 500 metres, altitude becomes the most important climate determinant. In these zones the temperatures and relative humidity are lower, thus generating mesothermal climatic conditions (type C climates), which give way to extremely cold climatic conditions (type E climates) in the highest mountain areas.

b) Precipitation: Precipitation in this system is highly variable and depends to a great extent on the local effects of the relief and the circulation of low-lying air masses. The least rainfall occurs in Colombia in the Guajira peninsula on the Caribbean sea, where the amount of rainfall is less than 300 mm annually. The figure rises to about 600 mm around Ríohacha and Santa Marta. The rainy season in these zones is from May to November (summer and autumn). In general, the amount of precipitation increases as one moves southward to more than

2 000 mm in the mountainous areas. In the area of the lower Atrato, in the northern part of the Department of Chocó, total precipitation is about 4 000 mm annually.

In the greater Magdalena river basin there are a number of sub-basins exhibiting differing characteristics. In the basins of the Suárez and Chicamocha rivers, mean annual precipitation is 1 100 mm. Further south, in the area of the Fusagasugá, Coello and Saldaña rivers (departments of Cundinamarca, Tolima and Huila respectively), precipitation totals around 1 600 mm annually, with a dry season in winter (December to March). The César River basin (in the Department of César) is relatively dry, with annual precipitation of about 1 000 mm: the mean increases to 2 000 mm and more in the mountainous zones (towards the Perijá range).

In the Cauca River valley, annual precipitation varies between 1 000 and 1 800 mm, and increases to over 2 000 mm in some locations, such as Chinchiná and Manizales. In the northern portion of Antioquía, in the same basin, annual rainfall ranges from 2 500 to 3 000 mm. The least amount of precipitation occurs in the winter (December to March).

In the Central American portion of the hydrographic system, which extends from Panama to Guatemala and Belize, the rainfall pattern is determined by the relief (a mountain chain having Atlantic and Pacific watersheds) and by the Equatorial air masses that circulate in various directions towards the continent. Mean annual precipitation is over 5 000 mm in some locations in Costa Rica. This rainfall occurs mainly in the summer (May to October) and diminishes as one proceeds inland from the Atlantic coast (see map 8.3 and table 8.1).

c) Temperature: The area corresponding to the Caribbean hydrographic system is markedly tropical and has very stable temperatures, with the daily temperature variation being greater than the annual variation. As in the case of rainfall, the temperatures vary with altitude, dropping as low as 0°C at the peaks of the mountains encircling the hydrographic system. Despite the distance from the Equator, annual temperature fluctuations are small due to the influence exerted by the Atlantic Ocean over the narrow strip of projecting land that forms Central America. Mean annual temperatures are high (up to 28°C) in the lowlands and generally decline as one moves inland to higher altitudes (see table 8.1).

3. Geomorphology and soils

The western boundary of the Caribbean hydrographic system is formed by a series of mountain chains which separate it from the Tropical Pacific hydrographic system and which together form the Andes Mountains. In the South American portion of the system, the ridge

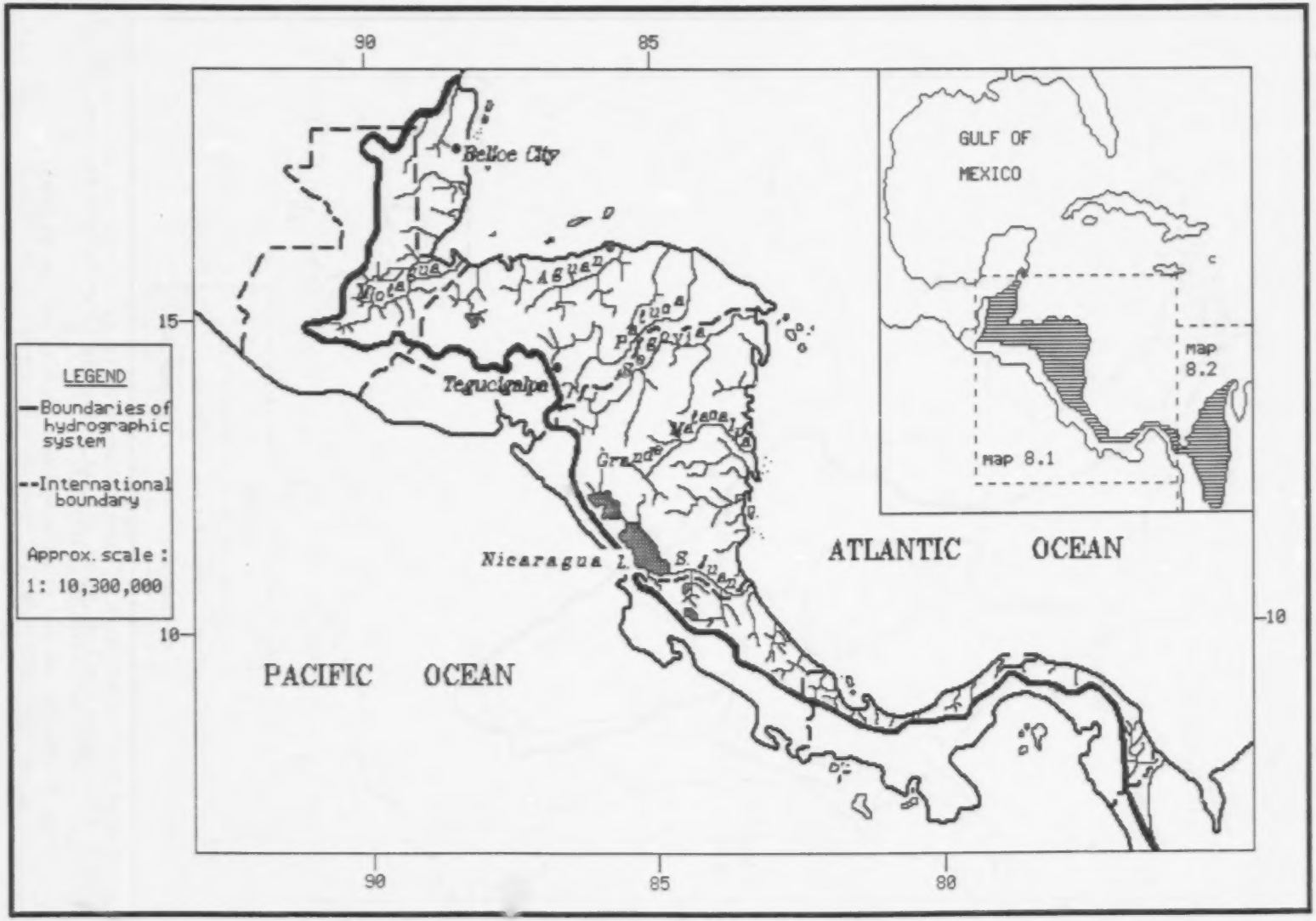
of mountains forming its eastern boundary start from the Andean knot of Pasto, located to the south of the city of Papayán in Colombia, and extend along the eastern branch of the Andes (the Perijá range) up to the Oca fault in the Guajira peninsula. In the Central American portion of the system, the basins on the Caribbean or Atlantic side typically have milder slopes and longer rivers than the basins on the Pacific side due to the asymmetrical configuration of the mountain chain. Generally speaking, the topography of the Caribbean slope permits a better regulation of flow through the use of storage dams, thanks to the milder gradient and to the fact that the peak flows of the rivers are of longer duration and their flood peaks are lower.

In Costa Rican and Panamanian territory, the topography is such that there are no large natural depressions that would permit a proper regulation of streamflows. This area's combination of steep slopes and normally heavy rainfall gives rise to broad rivers and to frequent flooding when these watercourses are not adequately controlled.

The topography of the Magdalena and Cauca river basins in Colombia --the main South American component of this hydrographic system-- is mountainous in the middle and upper portions of the basins but gives way to flatter land in the alluvial plains of the lower Magdalena. These two basins are separated by the central Andean range and meet at its outermost spurs. The Sinú and Atrato river basins to the west of the Magdalena also empty into the Caribbean.

From a structural geological and edaphic standpoint (see map 8.3), the entire hydrographic system is strongly influenced by the Andean mountain range system. The upper reaches of this range are composed mainly of tertiary volcanic rock (andesite and rhyolite) which are covered in some places by recent volcanic layers, especially pumice ash. Owing to the intense volcanic activity that took place during the recent Quaternary, large amounts of volcanic sediments have been deposited in the valleys, giving rise to fertile, productive soil in the areas where lahars (deposits of volcanic ash) and pyroclastic deposits have formed (luvisols and cambisols). In the flat lowlands of the basins --mainly in the swamplands or areas prone to flooding-- there are vast tracts of hydromorphic soils composed of sedimentary and alluvial material which has been carried down by the rivers from the upper basins (gleysols, fluvisols and histosols). This is the case, for example, in the areas around the mouths of the Motagua River in Guatemala, the Ulúa, Aguán and Patuca rivers in Honduras; the Coco or Segovia River along the Honduran/Nicaraguan border; the Wawa, Bambana, Grande Matagalpa, Kurinwás and Escondido rivers in Nicaragua; the

San Juan River along the Nicaraguan/Costa Rican border; and the Atrato, Sinú and Magdalena rivers in Colombia. The best soils (andosols) are generally found in the terraces formed by the rivers as they carved out the Andean valleys during the various glacial and para-glacial periods (see table 8.2).

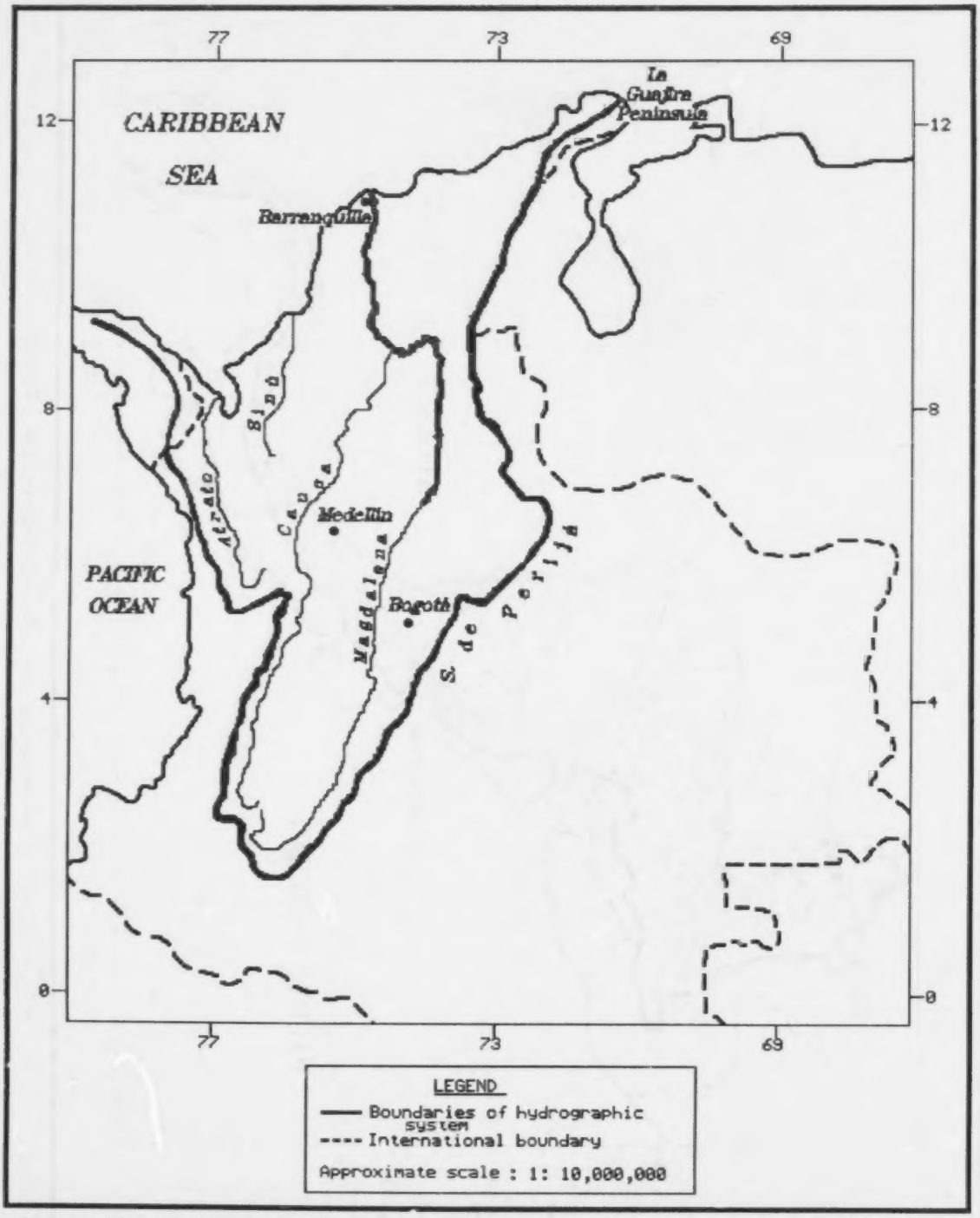


Map 8.1

Source: ECLAC, Water Resources Unit, Natural Resources and Energy Division.

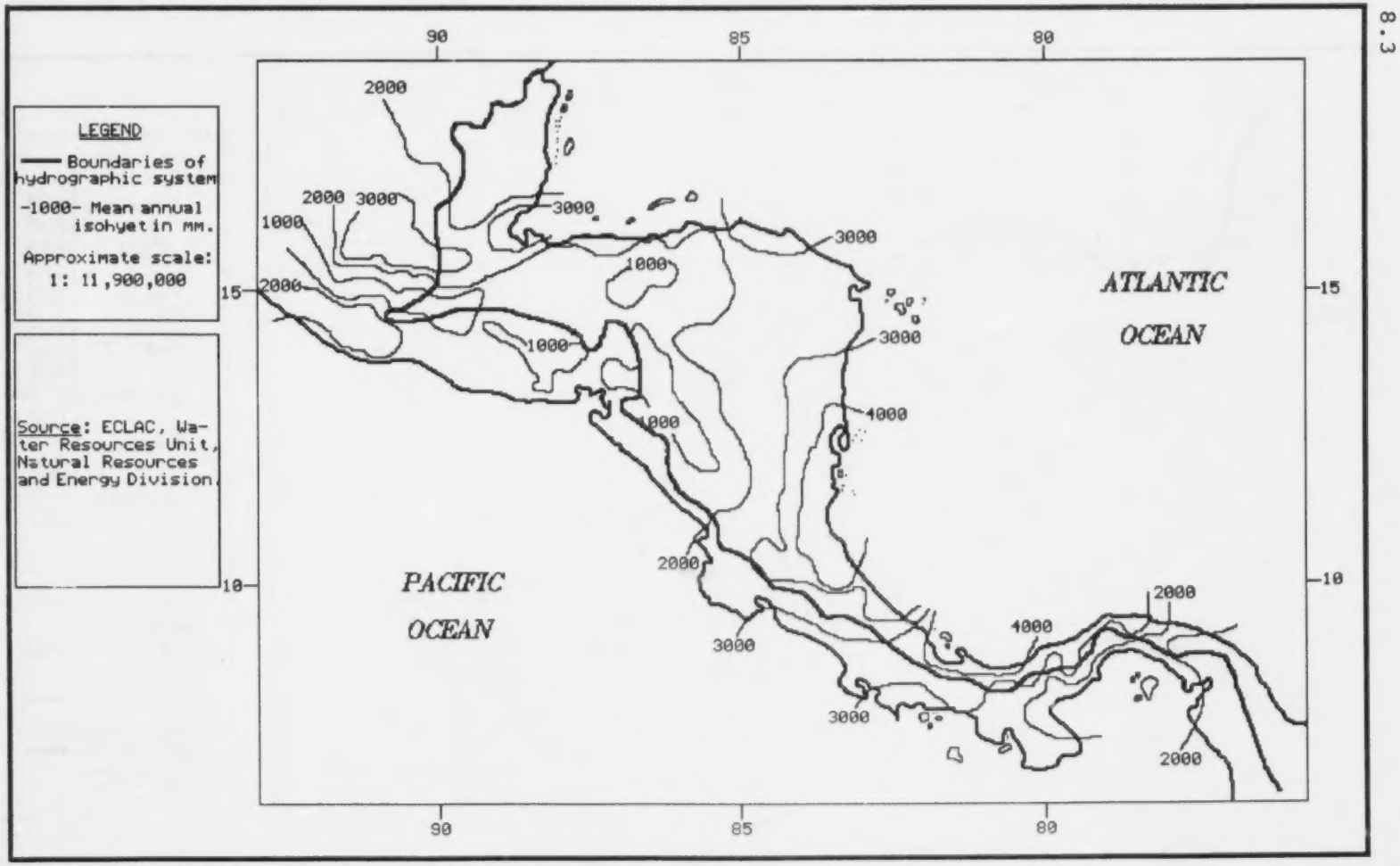
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 8.2

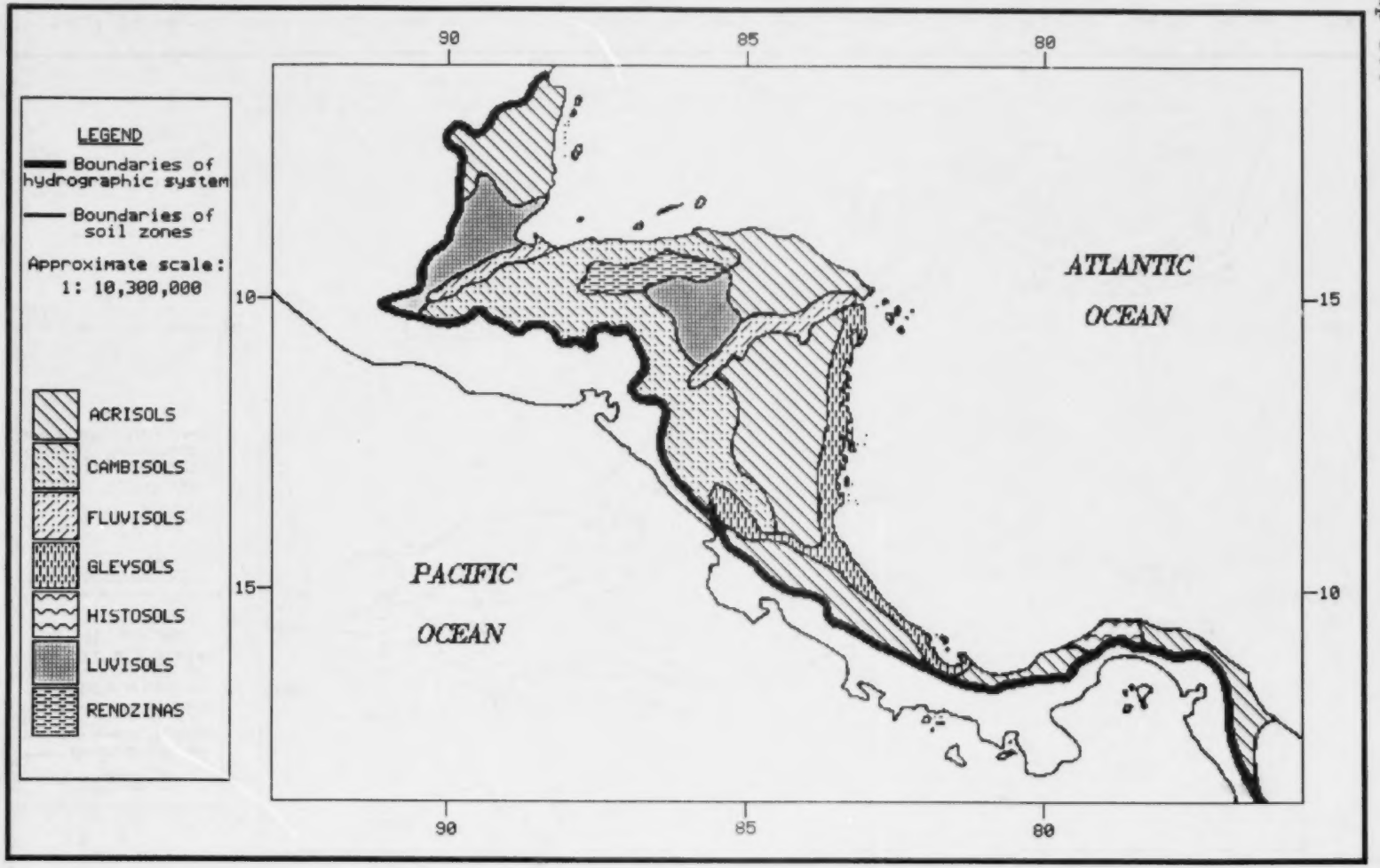


Source: Adapted from United Nations Economic Commission for Latin America (ECLAC), Los recursos hidráulicos de América Latina, Bolivia y Colombia (E/CN.12/695), New York, 1964. United Nations publication, sales N°: 64.II.G.11.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.



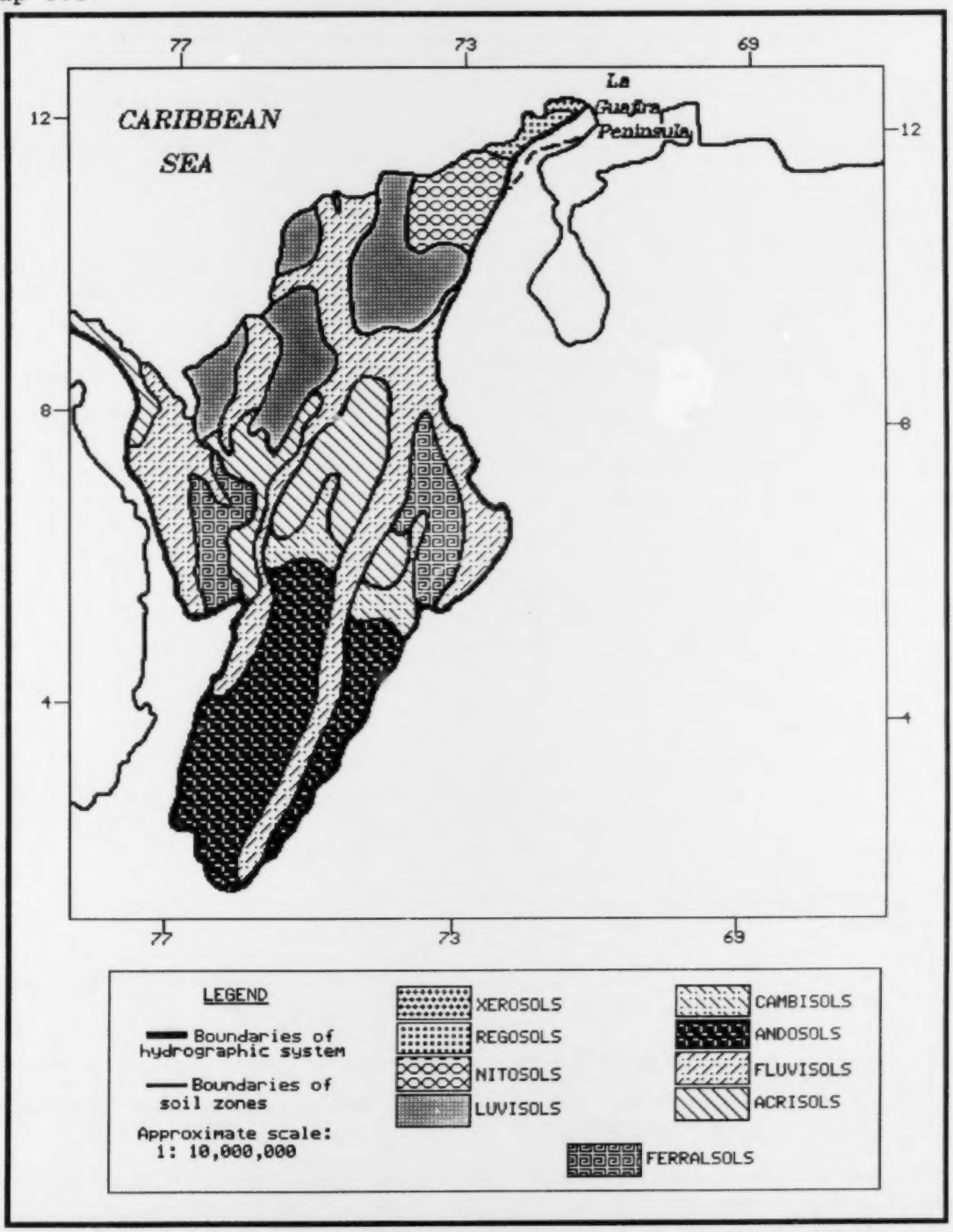
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.



Source: ECLAC, Water Resources Unit, Natural Resources and Energy Division.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 8.5



Source: Adapted from United Nations Economic Commission for Latin America (ECLAC), Los recursos hidráulicos de América Latina, Bolivia y Colombia (E/CN.12/695), New York, 1964. United Nations publication, sales N°: 64.II.G.11.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 8.1

CARIBBEAN HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 8.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
BARRANQUILLA, Colombia (30)												
10°54'N-74°46'W												
Altitude: 14 m												
mmp (map: 846 mm)	1	0	1	11	87	103	54	102	138	202	82	65
mmt (mat: 28.1°C)	26.8	26.9	27.4	28.4	28.9	28.7	28.7	28.9	28.6	28.2	28.1	28.0
Climate: Aw												
TEGUCIGALPA, Honduras (31)												
14°03'N-87°13'W												
Altitude: 1 006 m												
mmp (map: 920 mm)	11	5	9	29	152	164	88	95	182	133	39	13
mmt (mat: 21.7°C)	19.5	20.6	21.8	23.2	23.5	23.4	22.5	22.7	22.9	21.9	20.8	19.8
Climate: Af												
BOGOTA, Colombia (86)												
04°42'N-74°08'W												
Altitude: 2 547 m												
mmp (map: 989 mm)	52	55	88	124	108	58	49	50	58	151	122	74
mmt (mat: 13.2°C)	12.8	13.2	13.7	13.7	13.7	13.2	12.9	12.9	12.8	12.9	13.1	13.1
Climate: Cf												
MEDELLIN, Colombia (30)												
06°13'N-75°36'W												
Altitude: 1 498 m												
mmp (map: 1 325 mm)	41	49	75	147	178	112	105	133	129	160	114	82
mmt (mat: 21.4°C)	21.2	21.7	21.7	21.8	21.7	21.7	21.5	21.5	21.3	21.1	21.1	20.9
Climate: Aw												
BELICE City, Colombia (39)												
17°30'N-88°11'W												
Altitude: 5 m												
mmp (map: 1 866 mm)	136	63	38	51	105	205	163	168	235	307	209	185
mmt (mat: 25.9°C)	23.5	24.2	25.5	26.7	27.3	27.3	27.2	27.6	27.2	26.1	24.4	23.6
Climate: Af												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

Table 8.1 (concl.)

b/ The meanings of the abbreviations used in this column are:
- Af: tropical jungle climate
- Aw: tropical savanna climate
- Cf: temperate climate, constantly wet
- map: mean annual precipitation
- mmp: mean monthly precipitation
- mat: mean annual temperature
- mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

Table 8.2

CARIBBEAN HYDROGRAPHIC SYSTEM: FLOWS OF MAJOR RIVERS AND TRIBUTARIES

Major river	Primary tributary	Secondary tributary	Flow (m3/s)	Measurement site	Administrative division
(Colombia)					
Magdalena	Cauca		9.7	Cocunuco	Cauca
Magdalena	Cauca		141.2	Suárez	Cauca
Magdalena	Cauca		198.7	La Balsa	Cauca
Magdalena	Cauca		279.4	Juanchito	Valle
Magdalena	Cauca		562.6	La Virginia	Risaralda
Magdalena	Cauca	Bugalagrande	17.8	Bugalagrande	Valle
Magdalena	Cauca	Fraile	5.5	El Peñón	Valle
Magdalena	Cauca	Jamundi	5.2	Planta Eléctrica	Valle
Magdalena	Cauca	La Vieja	63.5	Calcedonia	Valle
Magdalena	Cauca	La Vieja	100.2	Cartago	Valle
Magdalena	Cauca	Palo	18.4	Arriba	Cauca
Magdalena	Cauca	Palo	24.8	Puerto Tejada	Cauca
Magdalena	Cauca	Rioclaro	7.1	Rioclaro	Valle
Magdalena	Cauca	Riofrío	16.3	Riofrío	Valle
Magdalena	Cauca	Risaralda	27.5	La Suiza	Risaralda
Magdalena	Cauca	Timba	25.4	Timba	Cauca
Magdalena	Cauca	Tulua	14.8	Mateguadua	Valle
Magdalena	Coello		43.2	Chicoral	Tolima
Magdalena	Fusagasuga	Sumapaz	34.5	San Bartolo	Cundinamarca
Magdalena	Lagunilla		2.6	El Bosque	Huila
Magdalena	Lebrija		19.8	Rocas	Santander
Magdalena	Sogamoso		332.6	El Tablazo	Santander
Magdalena	Sogamoso	Chicamocha	5.2	Termopaipa	Boyaca
Magdalena	Sogamoso	Fonce	60.5	San Gil	Santander
(Costa Rica)					
Banano			16.5	Asunción, 09°53'N-83°10'W	Limón
Pacuare			55.3	Siquirres, 10°05'N-83°29'W	Limón
Parismina	Reventazón		132.4	Pascua, 10°01'N-83°37'W	Limón
San Juan	San Carlos		56.5	Jabillos, 10°23N-84°32'W	Alajuela
(Guatemala)					
Belize	Mopan		35.9	El Arenal, 17°00'N-89°08'W	Petén
Dulce	Boca Nueva		11.8	Boca Nueva II, 15°22'N-89°39'W	Alta Verapaz
Dulce	Matanzas		38.2	Matacuy, 15°17'N-89°53'W	Alta Verapaz
Dulce	Polochic		69.9	Teleman, 15°20'N-89°44'W	Alta Verapaz
Dulce	Polochic	Cahabon	25.8	Chaicar, 15°29'N-90°17'W	Alta Verapaz
Motagua			66.8	Pte. Orellana, 15°55'N-90°00'W	El Progreso
Motagua			181.9	Morales, 15°28'N-88°49'W	Izabal
Motagua	Grande Zacapa		25.3	Camotan, 14°49'N-89°22'W	Chiquimula

Table 8.2 (concl.)

Major river	Primary tributary	Secondary tributary	Flow (m3/s)	Measurement site	Administrative division
(Honduras)					
Chamalecón			43.6	Pte. Chamalecón, 15°25'N-88°01'W	Cortés
Patuca			209.4	Cayetano, 14°27'N-85°59'W	Olancho
Patuca	Guayape		20.5	Guayabillas, 14°40'N-86°18'W	Olancho
Patuca	Guayape	Telica	9.0	Telica, 14°43'N-86°10'W	Olancho
Ulúa			86.4	Santa Bárbara, 14°52'N-88°15'W	Santa Bárbara
Ulúa			180.4	Chinda, 15°17'N-87°40'W	Cortés
Ulúa			195.5	Pte.Pimienta, 15°16'N-87°38'W	Cortés
Ulúa	Grande de Otoro		15.3	La Gloria, 14°27'N-88°02'W	Intibuca
Ulúa	Humuya		16.6	La Encantada, 14°30'N-87°40'W	Comayagua
Ulúa	Jicatuyo		74.1	Quecoa, 14°57'N-88°16'W	Santa Bárbara
(Nicaragua)					
Coco			52.2	Guanas, 13°36'N-86°00'W	Nueva Segovia
Grande de Matagalpa			3.2	Darío, 12°46'N-86°07'W	Matagalpa
Grande de Matagalpa	Tuma		12.7	El Dorado, 13°15'N-85°52'W	Jinotega
Grande de Matagalpa	Tuma		20.8	Yacica, 13°04'N-85°45'W	Jinotega
Lake Managua	Río Viejo		5.6	Santa Bárbara,12°46'N-86°13'W	Matagalpa
Lake Nicaragua	Malacatoya		5.7	Las Banderas, 12°20'N-85°57'W	Managua
San Juan			46.3	Tipitapa, 12°12'N-86°06'W	Managua
San Juan			563.6	Los Pilares, 11°09'N-84°26'W	Río San Juan
(Panamá)					
Changuinola			203.9	Bacon Bay, 09°25'N-82°31'W	Bocas del Toro
Coclé			48.4	El Torno, 08°54'N-80°34'W	Colón
Indio			20.8	Limón, 09°01'N-80°12'W	Colón
Lake Gatun	Chagres		30.2	Chico, 09°16'N-79°31'W	Colón

Source: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama: United Nations Development Programme (UNDP) and World Meteorological Organization (WMO), Rol de estaciones hidrológicas y meteorológicas en el istmo centroamericano, San José, Costa Rica, 1968, Publication No. 23 of the Project on the expansion and improvement of hydrometeorological and hydrological services in the Central American Isthmus, preliminary edition; Colombia: Economic Commission for Latin America and the Caribbean (ECLAC), Los recursos hidráulicos de América Latina. Bolivia y Colombia, (E/CN.12/695), New York, 1964, United Nations publication, Sales No:64.II.G.11.

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication, information was not available on iron and steel industries or non-ferrous metals industries in this hydrographic system.

Table 8.3

DAMS IN THE CARIBBEAN HYDROGRAPHIC SYSTEM

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Colombia)					
Anchicaya	Anchicaya	1952	2 300	H	Valle del Cauca
Anchicaya	Alto Anchicaya	1974	45 000	H	Valle del Cauca
Arroyo Grande	Arroyo Grande	1969	127 000	I	Bolívar
Arroyo Matuya	Arroyo Matuya	1971	102 000	I	Bolívar
Calderas	Calderas	1984	2 500	...	Antioquía
Calima	Calima I	1965	563 000	H	Valle del Cauca
Campoalegre	San Francisco	1969	9 000	H	Caldas
Cauca	Salvajina	1985	904 000	H,C,I	Cauca
Chinchiná	Cameguadua	1951	1 000	H	Caldas
Guadalupe	Troneras	1962	49 000	H	Antioquía
Guatape	Punchina	1982	72 000	H	Antioquía
La Garcia-La Gallinaza	La Garcia	1951	2 100	H	Antioquía
Las Palmas	La Fe	1977	15 000	S	Antioquía
Magdalena	Betania	1984	1 971 000	H,I,S	Huila
Nare	Santa Rita Primera	1969	72 000	H	Antioquía
Nare	Santa Rita	1978	1 240 000	H	Antioquía
Nare	San Lorenzo	1985	196 000	H	Antioquía
Piedras Blancas	Piedras Blancas	1952	1 500	S	Antioquía
Prado	Prado	1971	1 400 000	H,I	Tolima
Río Grande	Quebradona	1958	3 200	H	Antioquía
Tenche	Tenche	1962	200	H	Antioquía
Tenche	Miraflores	1965	150 000	H	Antioquía
	Total - Colombia :		6 927 800		
(Costa Rica)					
Arenal	Arenal	1978	2 220 000	H,I	Alajuela
Grande	La Garita	1958	0	H	Alajuela
Reventazón	El Llano	1963	400	H	Cartago
Reventazón	Cachi	1966	51 000	H	Cartago
	Total - Costa Rica :		2 271 400		

Table 8.3 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Honduras)					
Enea	Enea (Lake Yojoa)	1964	1 926 000	H	Cortés
Guacerique	Los Laureles	1976	9 500	S	Francisco Morazán
Pescadero	El Pescadero (Lake Yojoa)	1964	1 926 000	H	Cortés
San José	El Coyolar	1967	14 000	I	Comayagua
Tepemechín	La Pita (Lake Yojoa)	1977	1 926 000	H	Cortés
Varsovia	Varsovia (Lake Yojoa)	1977	1 926 000	H	Cortés
	Total - Honduras :		7 727 500		
(Nicaragua)					
Tuma	El Mancotal	1965	425 000	H	Matagalpa
Viejo	El Salto	1972	23 000	H	Matagalpa
	Total - Nicaragua :		448 000		
(Panamá)					
Lake Gatún	Gatún	1912	544 000	N,H	Colón
	Total - Panamá :		544 000		
(Venezuela)					
Asunción	La Asunción	1954	300	S	Nueva Esparta
Grande-Chiquito	Guatamare	1958	800	S	Nueva Esparta
San Juan	San Juan	1958	1 000	S	Nueva Esparta
	Total - Venezuela :		2 100		
	Total - Hydrographic system :		17 920 800		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Dams for which no reservoir capacity is given are lateral dams not used for water storage.

b/ Symbols used in "Purpose" column:

C: Flood control
H: Hydroelectricity
I: Irrigation
N: Navigation
S: Water supply

Table 8.4

CARIBBEAN HYDROGRAPHIC SYSTEM: HYDROELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Colombia)				
Anchicaya	Alto Anchicaya	340.0	Valle del Cauca	Buenaventura
Anchicaya	Anchicaya	64.0	Valle del Cauca	Buenaventura
Bogotá	Canoas	50.0	Cundinamarca	Bogotá
Bogotá	El Colegio	300.0	Cundinamarca	Bogotá
Bogotá	Laguneta	80.0	Cundinamarca	Bogotá
Bogotá	Salto Dos	66.0	Cundinamarca	Bogotá
Bogotá	Salto Uno	55.0	Cundinamarca	Bogotá
Calima	Calima	120.0	Valle del Cauca	Guga
Cauca	Florida II	24.0	Cauca	Popayán
Grande	Río Grande I	74.0	Antioquía	Medellín
Guadalupe	Guadalupe Uno Dos y Tres	310.0	Antioquía	Medellín
Guadalupe	Troneras	36.0	Antioquía	Medellín
Lebrija	Palmas	12.0	Santander	Bucaramanga
Nave	Guatape	560.0	Antioquía	Medellín
Negro	Río Negro	10.0	...	Honda
Prado	Río Prado	51.0	Tolima	Ibagué
San Eugenio	Esmeralda	30.0	Risaralda	Santa Rosa de Cabal
San Eugenio	San Francisco	135.0	Risaralda	Santa Rosa de Cabal
Soldana	Insula	15.0	Caldas	Manizales
	Total - Colombia :	2 332.0		
(Costa Rica)				
Macho	Río Macho	90.0	Cartago	Cartago
Reventazón	Cachi	64.0	Cartago	Cartago
	Total - Costa Rica :	154.0		
(Honduras)				
Lindo	Río Lindo	40.0	Santa Bárbara	Río Lindo
Ulúa	Cañaveral	29.0	Santa Bárbara	Santa Bárbara
	Total - Honduras :	69.0		
(Nicaragua)				
Tuma	Centroamérica	50.0	Jinotega	Jinotega
	Total - Nicaragua :	50.0		
	Total - Hydrographic system :	2 605.0		

Source: ECLAC, on the basis of official data.

Table 8.5

CARIBBEAN HYDROGRAPHIC SYSTEM: THERMOELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Colombia)				
Bogotá	Termozipa	66.0	Cundinamarca	Bogotá
Bogotá	Zipaguira	71.0	Cundinamarca	Zupaguria
Cauca	Yumbo	53.0	Valle del Cauca	Yumbo
Magdalena	El Río	103.0	Atlántico	Barranquilla
Magdalena	Honda	155.0	Tolima	Honda
Magdalena	La Unión	74.0	Atlántico	Barranquilla
Caribbean Sea	Compique	52.0	Bolívar	Cartagena
Caribbean Sea	Manga	50.0	Bolívar	Cartagena
	Total - Colombia :	624.0		
(Costa Rica)				
Grande de Tárcoles	San Antonio	31.0	Heredia	Heredia
	Total - Costa Rica :	31.0		
	Total - Hydrographic system :	655.0		

Source: ECLAC, on the basis of official data.

Table 8.6

CARIBBEAN HYDROGRAPHIC SYSTEM: OIL REFINERIES

River or body of water	Name of refinery	Barrels per day	Administrative division	Locality
(Colombia)				
Luisa	El Guamo	2 500	Tolima	El Guamo
Magdalena	Barrancabermeja	110 000	Santander	Barrancabermeja
Magdalena	La Dorada	5 000	Caldas	La Dorada
Caribbean Sea	Cartagena	5 000	Bolívar	Cartagena
	Total - Colombia :	122 500		
(Costa Rica)				
Caribbean Sea	Costarricence	12 000	Limón	Puerto Limón
	Total - Costa Rica :	12 000		
(Guatemala)				
Caribbean Sea	Guat California	11 000	Izábal	Puerto Barrios
	Total - Guatemala :	11 000		
(Honduras)				
Caribbean Sea	Puerto Cortés	14 000	Cortés	Puerto Cortés
	Total - Honduras :	14 000		
(Nicaragua)				
Lake Managua	Managua	16 000	Managua	Managua
	Total - Nicaragua :	16 000		
(Panamá)				
Lake Gatún	Panamá S.A.	100 000	Colón	Las Minas Colón
	Total - Panamá :	100 000		
	Total - Hydrographic system :	275 500		

Source: ECLAC, on the basis of data compiled by the Latin American Energy Organization (OLADE), 1979.

Table 8.7

CARIBBEAN HYDROGRAPHIC SYSTEM: PAPER AND PULP INDUSTRIES

River or body of water	Name of industry	Output (tons/year) Pulp	Paper	Locality	Administrative division
(Colombia)					
Bogotá	Cartonera Nac. Cía.Ltda Cartona	-	1 000	Bogotá	Cundinamarca
Bogotá	Empresa Papelera Soacha	-	2 000	Bogotá	Cundinamarca
Bogotá	Fca. de Papeles Finos	4 000	8 500	Bogotá	Cundinamarca
Bogotá	ICOPULPA	-	1 200	Bogotá	Cundinamarca
Bogotá	Ind. Papelera Andina Colombia	-	500	Bogotá	Cundinamarca
Cauca	Cartón de Colombia	18 000	123 200	Cali	Valle del Cauca
Cauca	Fabrica Nacional de Cartón	-	7 800	Cali	Valle del Cauca
Cauca	ICOPULPA	41 000	-	Cali	Valle del Cauca
Cauca	Producción de Papeles (PROPAL)	78 200	72 600	Cali	Valle del Cauca
Magdalena	Ind. Papelera Colombiana Zipa	-	1 900	Barranquilla	Atlántico
Medellín	Ind. de Cartón Villa Hnos.	-	1 000	Medellín	Antioquía
Medellín	Scott de Colombia	-	2 000	Medellín	Antioquia
Otún	Colombiana Universal de Papel	-	1 700	Pereira	Risaralda
Otún	Papeles Nac. y Cía. Ltda.	-	3 400	Pereira	Risaralda
	Total - Hydrographic system	: 141 200	226 800		

Source: ECLAC, on the basis of official data.

Table 8.8

CARIBBEAN HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

River or body of water	City	Population 1950	1960	1970	1980	Administrative division
(Colombia)						
Bogotá	Bogotá	715 250	1 661 935	2 557 461	3 974 813	Bogotá Federal District
Cauca	Armenia	78 380	125 022	135 415	180 221	Quindio
Cauca	Cali	284 186	618 215	901 714	1 323 944	Valle
Cauca	Palmira	80 957	106 502	140 481	175 186	Valle
Chinchina	Manizales	126 201	190 036	199 517	275 067	Caldas
Combeima	Ibagué	98 695	125 233	182 425	269 495	Tolima
Guatapuri	Valledupar	26 442	43 553	87 953	142 771	César
Lebrija	Bucaramanga	112 252	216 821	270 332	341 513	Santander
Magdalena	Barrancabermeja	35 493	59 625	87 191	137 406	Santander
Magdalena	Barranquilla	279 627	493 034	664 811	896 649	Atlántico
Magdalena	Neiva	50 494	75 886	105 551	178 130	Huila
Caribbean Sea	Cartagena	128 877	217 910	291 428	491 368	Bolívar
Caribbean Sea	Santa Marta	47 354	89 161	103 426	177 922	Magdalena
Medellín	Medellín	358 189	717 865	1 053 964	1 418 554	Antioquia
Otún	Pereira	115 342	147 487	172 302	233 271	Risaralda
Sinú	Montería	77 057	70 531	93 304	157 466	Córdoba
(Guatemala)						
Las Vacas	Guatemala	284 276	572 671	700 504	855 736	Guatemala
(Honduras)						
Chamelecón	San Pedro Sula	21 139	58 632	102 516	259 000	Cortés
Grande	Tegucigalpa	72 385	134 075	232 276	425 800	Francisco Morazán
(Nicaragua)						
Lake Managua	Managua		234 580	398 514	853 000	Managua

Source: James W. Wilkie and Stephen Haber (ed.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin American Center Publications, University of California, 1981, and ECLAC on the basis of official data.

Table 8.9

CARIBBEAN HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Belize) a/	22 963	91 000	4.0	109 771	4.8	142 847	6.2
Total - Belize :	22 963	91 000	4.0	109 771	4.8	142 847	6.2
(Colombia) b/							
Antioquía	63 612	2 477 299	38.9	3 176 695	49.9	3 888 067	61.1
Atlántico	3 388	717 406	211.7	1 028 934	303.7	1 428 601	421.7
Bogotá Federal District	1 587	1 697 311	1 069.5	2 861 913	1 803.3	3 982 941	2 509.7
Bolívar	25 978	694 853	26.7	980 606	37.7	1 197 623	46.1
Caldas	7 888	712 916	90.4	744 221	94.3	838 094	106.2
Cauca	11 723	242 879	20.7	286 742	24.5	318 335	27.2
César	22 905	260 917	11.4	470 055	20.5	584 631	25.5
Chocó	27 918	109 118	3.9	150 734	5.4	145 661	5.2
Córdoba	25 020	585 714	23.4	744 424	29.8	913 636	36.5
Cundinamarca	11 312	561 107	49.6	588 002	52.0	691 180	61.1
Guajira	20 848	147 140	7.1	249 637	12.0	255 310	12.2
Huila	19 890	416 289	20.9	486 853	24.5	647 756	32.6
Magdalena	23 188	528 493	22.8	720 902	31.1	769 141	33.2
Quindio	1 845	305 745	165.7	353 868	191.8	377 860	204.8
Risaralda	4 140	437 210	105.6	498 609	120.4	625 451	151.1
Santander	15 269	500 607	32.8	616 788	40.4	719 113	47.1
Sucre	10 917	311 494	28.5	412 047	37.7	529 059	48.5
Tolima	23 562	841 424	35.7	957 193	40.6	1 051 852	44.6
Valle	13 284	1 039 832	78.3	1 435 629	108.1	1 708 252	128.6
Total - Colombia :	334 273	12 587 752	36.4	16 763 851	47.9	20 672 563	58.6
(Costa Rica) b/							
Alajuela	9 025	228 638	25.3	309 730	34.3	406 564	45.0
Cartago	2 600	155 433	59.8	204 699	78.7	271 671	104.5
Heredia	2 900	85 063	29.3	133 844	46.2	197 575	68.1
Limón	9 400	68 385	7.3	115 143	12.2	168 076	17.9
Total - Costa Rica :	23 925	537 519	22.5	763 416	32.0	1 043 886	43.7
(Guatemala) b/							
Alta Verapaz	5 212	156 299	30.0	168 314	32.3	193 205	37.1
Chimaltenango	1 781	146 838	82.4	174 937	98.2	207 053	116.3
Chiquimula	2 376	149 752	63.0	158 177	66.6	168 863	71.1
El Progreso	1 922	65 582	34.1	73 122	38.0	81 188	42.2
Guatemala	106	40 543	381.4	55 409	521.3	65 560	616.7
Izábal	9 038	116 685	12.9	169 818	18.8	194 618	21.5
Jalapa	2 063	99 153	48.1	118 074	57.2	136 091	66.0

Table 8.9 (cont. 1)

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Guatemala)							
Petén	21 512	15 937	0.7	38 468	1.8	79 156	3.7
Quiché	838	24 994	29.8	29 869	35.7	32 818	39.2
Sacatepéquez	465	80 942	174.1	99 988	215.0	121 127	260.5
Sololá	987	100 274	101.6	118 359	120.0	143 452	145.4
Totonicapán	371	49 620	133.6	58 383	157.2	71 547	192.7
Zacapa	2 690	96 554	35.9	105 739	39.3	115 712	43.0
Total - Guatemala :	49 361	1 143 173	30.5	1 368 659	38.2	1 610 388	45.0
(Honduras) b/							
Atlántida	4 251	92 914	21.9	148 285	34.9	214 102	50.4
Colón	8 875	41 904	4.7	77 750	8.8	113 864	12.8
Comayagua	5 196	96 442	18.6	136 619	26.3	191 111	36.8
Copán	3 203	126 183	39.4	151 859	47.4	201 172	62.8
Cortés	3 954	200 099	50.6	369 616	93.5	542 693	137.3
El Paraíso	5 053	74 776	14.8	98 555	19.5	132 486	26.2
Francisco Morazán	4 768	170 657	35.8	272 158	57.1	393 761	82.6
Gracias a Dios	16 630	10 905	0.7	20 738	1.2	31 084	1.9
Intibuca	1 536	36 569	23.8	40 908	26.6	52 364	34.1
Islas de La Bahía	261	8 961	34.4	13 194	50.6	17 472	67.0
La Paz	932	24 240	26.0	26 418	28.3	33 134	35.5
Lempira	1 930	50 196	26.0	57 502	29.8	73 839	38.3
Ocotepeque	840	26 270	31.3	25 519	30.4	31 077	37.0
Olancho	24 351	110 744	4.5	151 436	6.2	206 775	8.5
Santa Bárbara	5 115	146 909	28.7	186 106	36.4	259 769	50.8
Yoro	7 939	130 547	16.4	195 037	24.6	271 430	34.2
Total - Honduras :	94 834	1 348 316	15.6	1 971 700	22.3	2 766 133	31.1
(Nicaragua) b/							
Boaco	4 271	71 615	16.8	70 850	16.6	96 299	22.5
Chontales	4 947	75 575	15.3	69 530	14.1	109 626	22.2
Estelí	2 173	69 257	31.9	78 630	36.2	111 775	51.4
Granada	992	65 643	66.2	73 150	73.7	123 872	124.9
Jinotega	9 640	76 935	8.0	92 340	9.6	136 510	14.2
Madriz	1 612	50 229	31.2	53 560	33.2	78 223	48.5
Managua	2 189	207 237	94.7	313 690	143.3	536 310	245.0
Masaya	690	76 580	111.0	94 200	136.5	163 245	236.6
Matagalpa	6 929	171 465	24.7	172 180	24.8	257 095	37.1
Nueva Segovia	3 594	45 900	12.8	66 650	18.5	128 152	35.7
Río San Juan	7 402	15 676	2.1	20 250	2.7	32 702	4.4
Zelaya	60 035	88 963	1.5	148 830	2.5	296 263	4.9
Total - Nicaragua :	104 474	1 015 075	10.7	1 253 860	13.5	2 070 072	22.3

Table 8.9 (concl.)

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Panamá) b/							
Bocas del Toro	8 917	32 600	3.7	43 531	4.9	53 487	6.0
Colón	7 465	85 332	11.4	109 605	14.7	137 997	18.5
Total - Panamá :	16 382	117 932	7.2	153 136	9.3	191 484	11.7
Total - Hydrographic system :	646 213	16 840 767	27.2	22 384 393	35.9	28 497 374	45.3

Source: Organization of American States (OAS), and Inter-American Statistical Institute (IASI), América en cifras, 1974. Situación demográfica: Estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

Note: The figures appearing under the headings 1960, 1970 and 1980 actually correspond to the census dates given for each country.

a/ The figures given for population and density for 1960 and 1970 are estimates. Date of census in Belize: 12/05/80.

b/ Dates of censuses: Colombia: 15/07/64, 24/10/73, 1985; Costa Rica: 31/03/63, 14/05/73, 10/06/84; Guatemala: 18/04/64, 26/03/73, 26/03/81; Honduras: 17/04/61, 06/03/74, 30/06/80 (estimates as of date shown); Nicaragua: 25/04/63, 20/04/71, estimates; Panama: 11/12/60, 10/05/70, 11/05/80.

IX. TROPICAL PACIFIC HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

The Tropical Pacific hydrographic system encompasses the entire western slope of the Andes mountain range and its continuation in Central America from the Gulf of Guayaquil (Ecuador) in the south up to the Suchiate River on the Mexican Guatemalan border in the north. This system covers a large zone of the Pacific coast within the tropics and has an approximate area of 348 495 km^2. The rivers in this system are short in length and have greater and more regular flows than those in the arid Pacific systems as a result of the tropical climate and heavy rainfall (see maps 9.1 and 9.2).

2. Climate

a) Climate types (Köppen classification): Two main factors determine the types of climates found in the Tropical Pacific hydrographic system. The first is latitude and the second is the altitude of some zones within the system. Due to the latitudes of this area, the climate is tropical (various subtypes of type A), with heavy precipitation, high temperatures and small annual and daily temperature variations. As the altitude increases, temperatures and relative humidity decline and the tropical conditions described above gradually give way to mesothermal climatic conditions (type C climate) and to barren plains or severe cold (type E climate) in the high mountain zones.

b) Precipitation: Precipitation in most of this system averages around 2 000 mm annually. However, due to a number of climatological and physiographic factors, the amount of rainfall in different areas of the zone ranges from about 300 up to 5 000 mm per annum. One such factor is the complex orography of the Andean spurs, which gives rise to rainfall in the mountains as a result of condensation due to adiabatic expansion in the middle and upper reaches of the Andes (June to October in the South American portion of the system) and to orographic rainfall caused by large cumulus

and cumulo-nimbus clouds which take form, spread and dissipate over the highest peaks of the mountain range (October to March in the South American portion).

Other elements also play a part in determining the rainfall cycles in this system. One is the belt of low pressure which forms in the Equatorial zone and causes a decrease in air density as a result of heating. Due to the presence of this low-pressure area, subtropical anticyclones carry moisture-laden winds into the zone, producing cloud cover and rainfall that tend to persist for extended periods of time. The greatest amount of rainfall occurs from October to March. Two other factors are the Humboldt and El Niño ocean currents. The former is a cold current which flows up from the southern Pacific, while the latter, is a warm current, which comes down from the North and Central American coasts. The influence of these two currents produces such contrasting situations as the extreme dryness (considering the latitude) of the Ecuadorian coast (300 mm) and annual precipitation of between 4 000 and 5 000 mm in the south-western part of Costa Rica. The least precipitation in the system is recorded along the southern coast of Ecuador and the high peaks of the Andes Mountains while the greatest rainfall occurs in the Andean spurs and intermontane valleys (see map 9.3 and table 9.1).

c) Temperature: The temperatures in the system are, generally speaking, a result of the different altitudes of the terrain. In the South American portion of the hydrographic system, the mean annual isotherms range from 25°C at the coast to 8°C in the highest reaches of the mountains. In the Central American part of the system, the temperature range is narrower due to the lower altitude of the mountains separating the Pacific and Atlantic watersheds, and the highest mean annual temperatures are observed on the coast (approximately 27°C). Annual temperature variations are small throughout the system (up to 3°C) since the entire system is within the intertropical zone (see table 9.1).

3. Geomorphology and soils

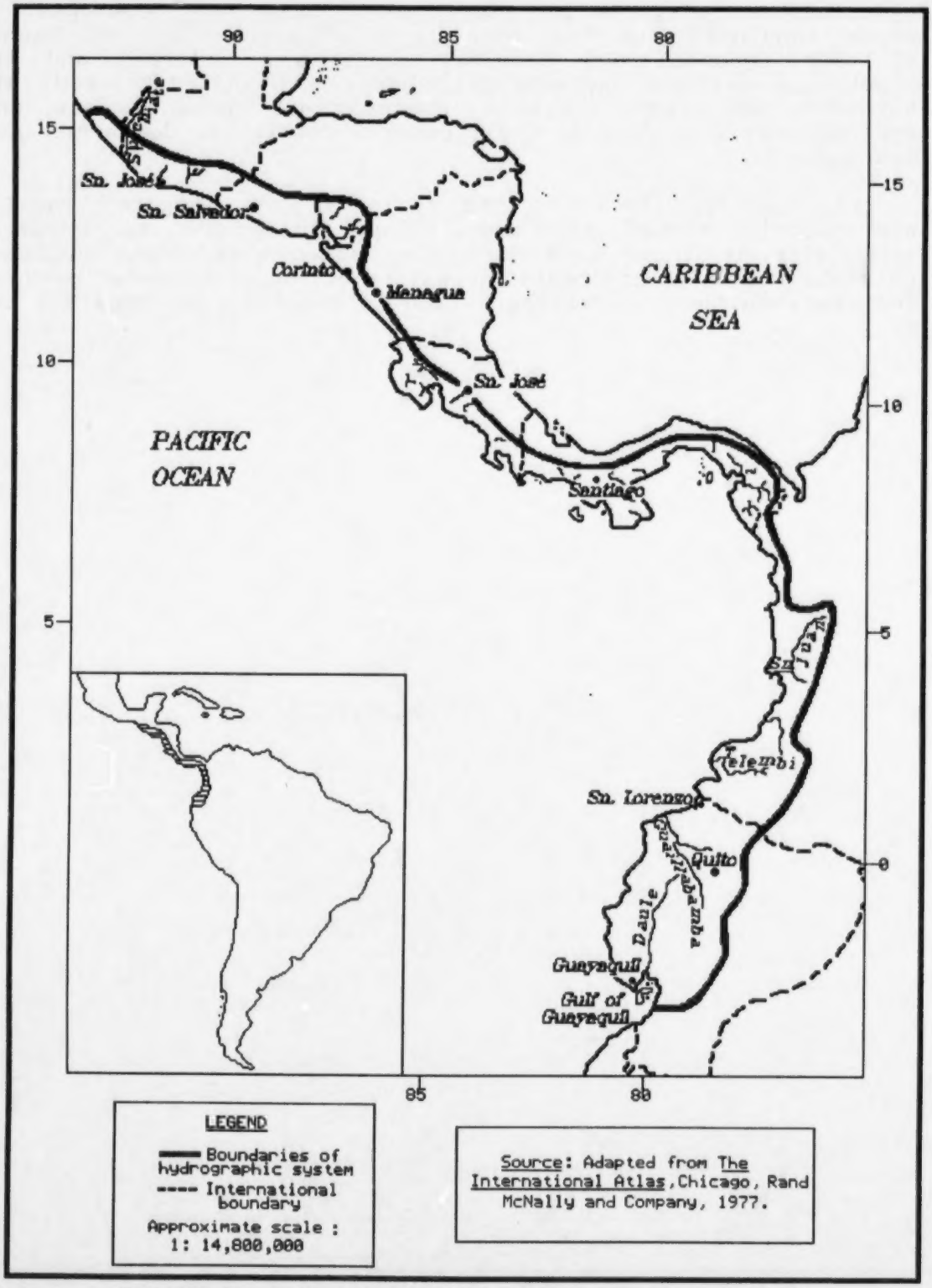
The western or Pacific side of the Andes range is characterized by steep slopes, deep river valleys and short alluvial plains in the flatlands near the coast. These physical features of the land vary according to the height of the mountains and their distance from the coast, and range from rolling hills to very rough terrain and steep slopes. The highest peaks reach up to 4 000 metres above sea level in the Central American part of the hydrographic system and over 6 000 m in its South American portion.

The prevailing climatic conditions give rise to humid alluvial (hydromorphic) soils in the flatlands, where the natural vegetation is of the tropical rainforest and very wet tropical forest type (see map 9.3). In some of the lowlands along the coast, saline

hydromorphic (gleysols and solonchaks) soils have developed, in which mangroves are the main form of vegetation. At higher altitudes andosol and cambisol soils are observed and the vegetation becomes increasingly sparse and underdeveloped. The nitosols, phaeozems, luvisols, andosols and cambisols are good agricultural soils due to their natural fertility, depth and good drainage.

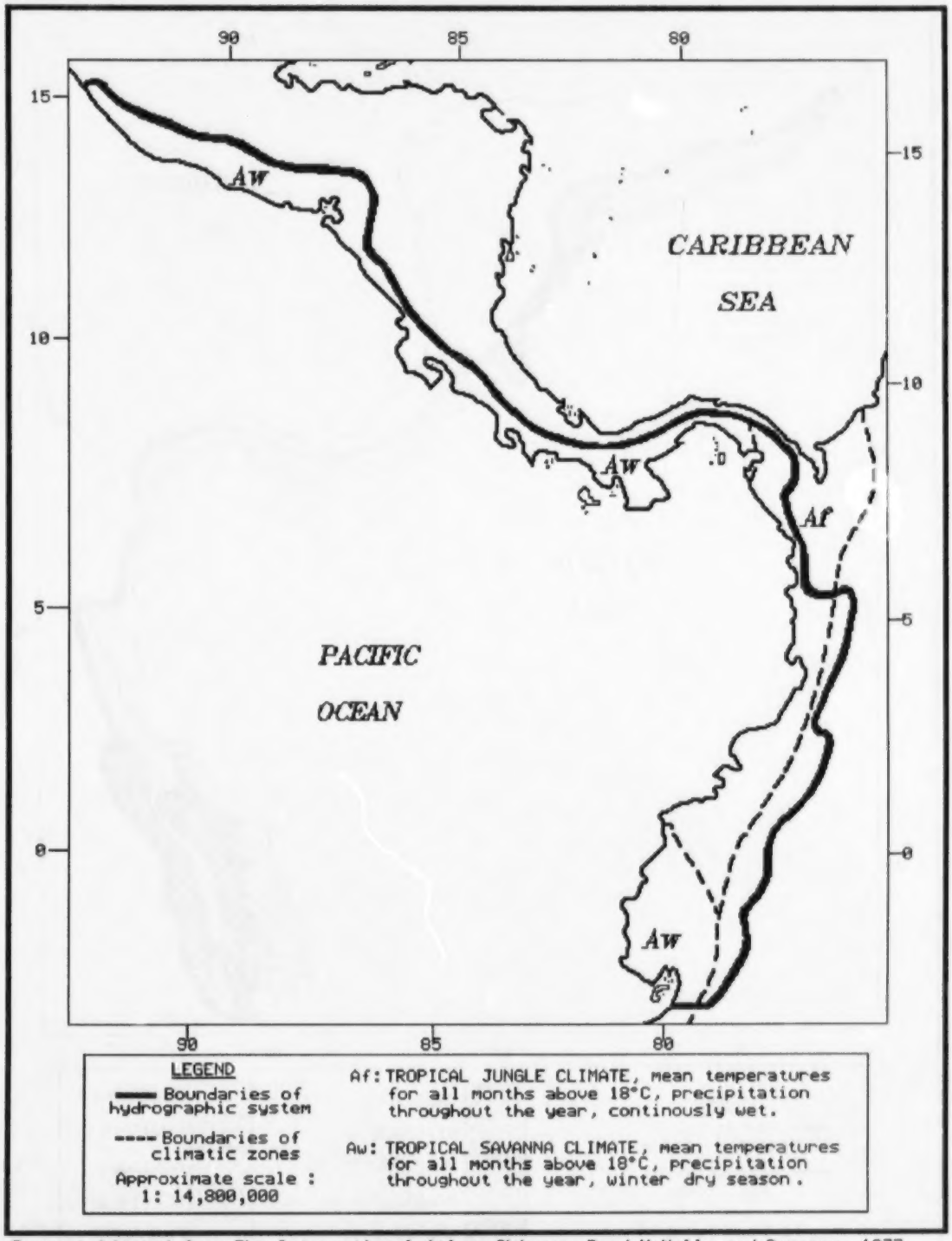
In general, however, the soils of the Tropical Pacific hydrographic system are fragile and vulnerable to erosion, especially in those sectors having steep gradients and heavy rainfall. Leaching and rapid denudation of the soils occur in these sectors when the natural vegetation is removed (see maps 9.4 and 9.5).

Map 9.1



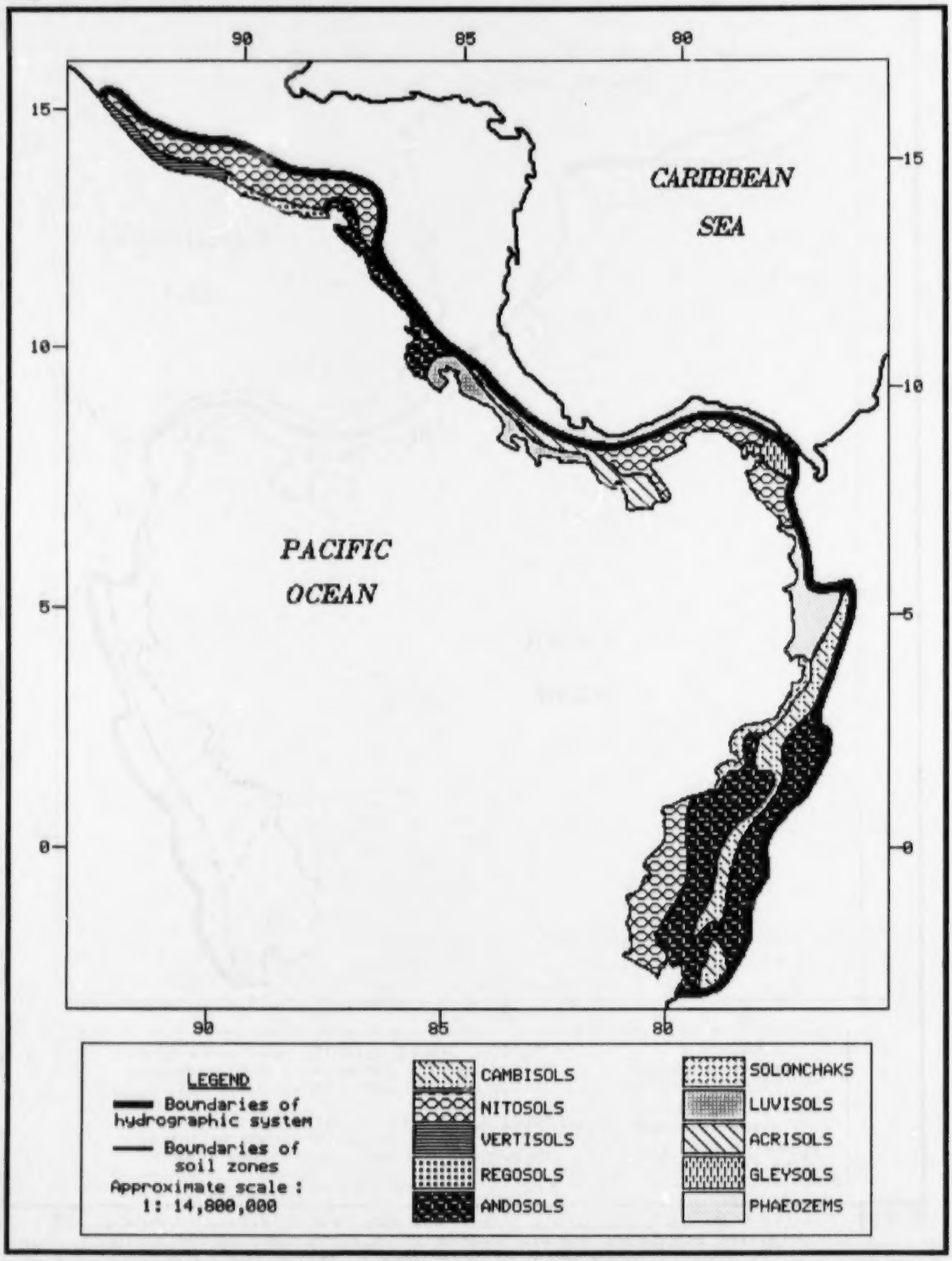
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 9.2



Source: Adapted from The International Atlas, Chicago, Rand McNally and Company, 1977.
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 9.3



Source: Adapted from The International Atlas, Chicago, Rand McNally and Company, 1977.
Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 9.1

TROPICAL PACIFIC HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 9.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
GUAYAQUIL, Ecuador (30)												
02°09'S-79°53'W												
Altitude: 9 m												
mmp (map: 936 mm)	191	229	250	173	46	10	4	7	1	2	4	19
mmt (mat: 24.9°C)	25.5	26.0	26.4	26.3	25.6	24.4	23.5	23.2	23.8	24.0	24.6	25.4
Climate: Aw												
MANAGUA, Nicaragua (28)												
12°07'N-86°11'W												
Altitude: 53 m												
mmp (map: 1 184 mm)	3	1	3	11	147	211	136	110	216	292	44	10
mmt (mat: 27.3°C)	26.3	27.2	28.6	29.3	29.4	27.2	26.9	27.2	26.9	26.5	26.3	26.1
Climate: Aw												
QUITO, Ecuador (74)												
00°09'S-78°29'W												
Altitude: 2 811 m												
mmp (map: 1 185 mm)	114	127	150	171	122	47	20	23	77	125	108	101
mmt (mat: 14.8°C)	15.0	15.0	15.0	14.7	14.7	14.5	14.5	15.0	15.0	15.0	14.7	15.0
Climate: Cwb												
SAN JOSE, El Salvador (30)												
13°55'N-90°49'W												
Altitude: 2 m												
mmp (map: 1 435 mm)	-	1	6	27	107	283	227	223	274	245	38	4
mmt (mat: 27.6°C)	25.8	26.5	27.7	28.8	28.8	28.3	28.2	28.1	27.6	27.4	27.4	26.7
Climate: Aw												
SAN SALVADOR, El Salvador (66)												
13°43'N-89°10'W												
Altitude: 680 m												
mmp (map: 1 781 mm)	6	5	9	54	187	318	307	297	314	235	38	10
mmt (mat: 23.3°C)	22.4	22.8	23.8	24.4	24.3	23.5	23.6	23.6	23.1	22.9	22.6	22.5
Climate: Aw												
SAN JOSE, Costa Rica (88)												
09°56'N-84°05'W												
Altitude: 1 171 m												
mmp (map: 1 868 mm)	11	4	13	44	221	269	213	240	325	332	149	46
mmt (mat: 20.5°C)	19.2	19.4	20.4	21.1	21.4	20.4	20.7	21.0	21.0	20.7	20.1	19.7
Climate: Aw												

Table 9.1 (concl.)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
SAN LORENZO, Ecuador (30)												
01°15'N-78°49'W												
Altitude: 6 m												
mmp (map: 2 548 mm)	255	288	294	347	286	290	204	115	114	126	86	143
mmt (mat: 25.8°C)	25.6	26.1	26.3	26.2	26.1	25.8	25.5	25.4	25.6	25.6	25.5	25.5
Climate: Af												
SANTIAGO, Panama (30)												
08°05'N-80°57'W												
Altitude: 80 m												
mmp (map: 2 659 mm)	33	22	20	116	344	315	255	372	377	465	269	71
mmt (mat: 26.7°C)	26.3	27.0	27.8	28.1	27.2	26.7	26.6	26.5	26.3	26.1	26.2	26.0
Climate: Aw												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

b/ The meanings of the abbreviations used in this column are:
- Af: tropical jungle climate
- Aw: tropical savanna climate
- Cwb: mesothermal temperate climate, dry season in winter
- map: mean annual precipitation
- mmp: mean monthly precipitation
- mat: mean annual temperature
- mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

Table 9.2

TROPICAL PACIFIC HYDROGRAPHIC SYSTEM: FLOWS OF MAJOR RIVERS AND TRIBUTARIES

Major river	Primary tributary	Secondary tributary	Flow (m3/s)	Measurement site	Administrative division
(Colombia)					
Anchicaya			86.3	Queremal	Valle
Anchicaya			97.0	Llano Bajo	Valle
Cajambre	Aguasucia		42.0	West of Cali	Valle
Micay			55.0	El Mango	Cauca
Micay			295.0	López	Cauca
Micay			430.0	Zaragoza	Cauca
Micay	Chuare		70.0	Chuare	Cauca
Micay	Mechenque		49.0	Before joins Micay River	Cauca
Mira			570.0	Caunapi	Narino
Mira	Guiza		60.0	Cartagena	Narino
Mira	Guiza		114.0	El Diviso	Narino
Naya			53.0	Alto Naya	Valle
Naya			91.0	Before joins Guatala River	Valle
Naya			175.0	Where joins Guatala River	Valle
Patía			343.0	Near where joints Guaitara River	Nariño
Patía			497.0	North of Magui	Nariño
Patía	Guaitara		39.0	Consaca	Nariño
Patía	Guaitara		43.0	Sandona	Nariño
Patía	Guaitara		59.0	Linares	Nariño
Patía	Juanambu		25.0	San Lorenzo	Nariño
Patía	Juanambu		45.0	San Lorenzo	Nariño
Patía	Telembi		117.0	Barbacoas	Nariño
Patía	Telembi	Cristal	34.0	Barbacoas	Nariño
Patía	Telembi	Nambi	59.0	Buenavista	Nariño
Patía	Telembi	Saspi	44.0	Barbacoas	Nariño
Raposo			113.0	Raposo	Valle
San Juan			300.0	Itsmina	Chocó
San Juan			2 500.0	Cabeceras	Chocó
San Juan	Calima		133.0	Darien	Chocó
San Juan	Tamaná		205.0	San José del Palmar	Chocó
(Costa Rica)					
Barranca			13.2	Nagatac, 10°03'N-84°39'W	Puntarenas
Bebedero	Corobici		10.6	Corobici, 10°27'N-85°08'W	Guanacaste
Grande Candelaria			30.3	El Rey, 09°40'N-84°18'W	San José
Grande de Tárcoles			78.4	Balsa, 09°56'N-84°28'W	Alajuela
Grande de Tárcoles	Poas		12.3	Tacares, 10°01'N-84°19'W	Alajuela
Grande de Tárcoles	Virilla		33.4	San Miguel, 09°55'N-84°24'W	Alajuela

Table 9.2 (cont.1)

Major river	Primary tributary	Secondary tributary	Flow (m3/s)	Measurement site	Administrative division
Grande de Térraba			306.4	Palmar, 08°58'N-83°28'W	Puntarenas
Grande de Térraba	General		70.8	Cristo Rey, 09°16'N-83°37'W	Puntarenas
Tempisque			26.0	Guardia, 10°34'N-85°36'W	Guanacaste
Tempisque	Colorado		4.1	Colorado, 10°40'N-85°29'W	Guanacaste
(Ecuador)					
Cañar			11.4	Pacay, 02°31'S-79°02'W	Cañar
Cañar			26.6	Tisay, 02°30'S-79°14'W	Cañar
Esmeraldas	Blanco		48.6	Los Bancos, 00°00'S-78°55'W	Pichincha
Esmeraldas	Blanco	Toachi	18.1	Guarumal, 00°36'S-78°55'W	Pichincha
Esmeraldas	Blanco	Toachi	102.7	Río Lelia, 00°19'S-79°02'W	Pichincha
Esmeraldas	Guayllabamba		179.4	Mandariacu, 00°12'N-78°53'W	Pichincha
Esmeraldas	Guayllabamba		912.0	Quninde, 00°21'N-79°23'W	Esmeraldas
Esmeraldas	Guayllabamba	San Pedro	30.4	San Pedro, 00°10'S-78°24'W	Pichincha
Guayas	Babahoyo	Chimbo	20.1	Chillanes, 01°55'S-79°03'W	Bolívar
Guayas	Babahoyo	Quevedo (Bimbe)	8.0	Bimbe, 00°35'S-79°17'0	Cotopaxi
Jubones			33.0	Minas, 03°20'S-79°23'W	Azuay
Jubones			47.8	La Unión, 03°20'S-79°36'W	El Oro
Jubones	León		12.3	Charcaloma, 03°25'S-79°10'W	Azuay
Mira			80.1	Caliche, 00°46'N-78°16'W	Carchi
Mira			85.7	Parambas, 00°49'N-78°19'0	Carchi
Mira			104.9	Cachaco, 00°50'N-78°24'W	Carchi
Mira			111.0	Where joins Lita, 00°52'N-78°26'W	Carchi
Mira	Chota		28.0	Chota, 00°28'N-78°02'W	Carchi
Mira	Verde		22.6	San Vicente, 00°47'N-78°26'W	Imbabura
Túmbes	Puyango		82.0	Maracabeli, 03°50'S-79°56'W	El Oro
Túmbes	Puyango	Pindo	47.8	Portovelo, 03°47'S-79°40'W	El Oro
(El Salvador)					
Banderas			13.3	Highway bridge, 13°31'N-89°44'W	Sonsonate
Grande San Miguel			27.8	Vado Marín, 13°18'N-88°15'W	San Miguel
Goascorán			33.7	Near Pacific Ocean outlet, 13°36'N-87°46'W	La Unión
Jiboa			7.6	Litoral Bridge, 13°30'N-89°59'W	Sonsonate
Lempa			377.5	San Marcos, 13°26'N-88°42'W	Usulután
Lempa	Acelhuate		11.5	Where joins Lempa, 14°02'N-89°07'W	Chalatenango
Lempa	Sucio		15.2	San Andrés, 13°48'N-89°24'W	Santa Ana
Lempa	Suquiapa		7.3	Tapachico, 13°59'N-89°20'W	Chalatenango
Lempa	Torola		40.1	Osicala, 13°50'N-88°08'W	Morazán
Paz			27.2	La Hachadura, 13°51'N-90°06'W	Jutiapa
Sirama			5.4	Sirama, 13°28'N-87°51'W	La Unión
Sonsonate			6.1	Sensunapán, 13°36'N-89°49'W	Sonsonate

Table 9.2 (concl.)

Major river	Primary tributary	Secondary tributary	Flow (m3/s)	Measurement site	Administrative division
(Guatemala)					
Coyolate	Xaya		0.6	La Sierra, 14°25'N-91°03'W	Chimaltenango
Los Esclavos			10.6	La Sonrisa, 14°15'N-90°16'W	Santa Rosa
Los Esclavos	Tapalapa		2.0	Poza Escondida, 14°26'N-90°08'W	Santa Rosa
Madre Vieja			1.4	Panibaj, 14°38'N-91°08'W	Suchitepéquez
Madre Vieja			9.8	Palmira, 14°26'N-91°12'W	Suchitepéquez
María Linda	Aguacapa		10.9	Agua Caliente, 14°15'N-91°27'W	Escuintla
Nahualate			2.1	Santa Catarina, 14°43'N-91°22'W	Solola
Samala			9.8	Candelaria, 14°37'N-91°35'W	Retalhuleu
(Honduras)					
Choluteca			11.9	Hernando López, 14°17'N-87°11'W	Choluteca
Choluteca			16.4	Paso La Ceiba, 14°15'N-87°08'W	Choluteca
Choluteca			33.7	Los Encuentros, 13°28'N-87°05'W	Choluteca
(Nicaragua)					
Tamarindo			2.9	Tamarindo, 12°14'N-86°42'W	León
(Panama)					
Caimito			6.8	La Chorrera, 08°54'N-80°34'W	Coclé
Chepo	Bayano		159.0	Maje, 09°09'N-78°45'W	Panama
Chepo	Bayano		182.4	Cañitas, 09°12'N-78°55'W	Panama
Chiriquí			123.7	David, 08°22'N-82°49'W	Chiriquí
Chiriquí Viejo			52.9	Paso Canoa, 08°35'N-82°49'W	Chiriquí
Fonseca			60.8	San Lorenzo, 08°23'N-82°05'W	Chiriquí
Grande			19.2	Río Grande, 08°24'N-80°31'W	Coclé
La Villa			16.6	Macaracas, 07°44'N-80°33'W	Coclé
San Pablo			52.7	La Mesa, 08°08'N-81°16'W	Veraguas
Santa María			80.9	San Francisco, 08°13'N-80°50'W	Veraguas
Santa María	San Juan	Gatun	25.9	San Juan, 08°20'N-81°01'W	Veraguas
Tabasara			73.1	Camarón, 08°07'N-81°37'W	Veraguas

Source: Costa Rica, Guatemala, Honduras, Nicaragua and Panama: United Nations Development Programme (UNDP) and World Meteorological Organization (WMO), Rol de estaciones hidrológicas y meteorológicas en el istmo centroamericano, San José, Costa Rica, 1968, Publication No. 23 of the Project on the expansion and improvement of hydrometeorological and hydrological services in the Central American isthmus, preliminary edition; Colombia: ECLAC, Los recursos hidráulicos de América Latina. Bolivia y Colombia (E/CN.12/695), New York, 1964, United Nations publication, Sales No: 64.II.G.11; Ecuador: Ministry of Natural and Energy Resources/Ecuadorian Electrification Institute (INECEL), Plan maestro de electrificación. Catálogo de proyectos hidroeléctricos, Quito, 1983.

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication, information was not available on iron and steel industries or non-ferrous metals industries in this hydrographic system.

Table 9.3

DAMS IN THE TROPICAL PACIFIC HYDROGRAPHIC SYSTEM

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Colombia)					
Mayo	Mayo	1969	380	H	Nariño
	Total Colombia :		380		
(Costa Rica)					
Grande de Térraba	Boruca	1983	14 960 000	H	Puntarenas
	Total Costa Rica :		14 960 000		
(Ecuador)					
Azúcar	El Azúcar	1969	12 000	I	Guayas
Chulco	El Labrado	1952	6 000	H,I	Azuay
Paute	Daniel Palacios	1983	120 000	H	Azuay
Pisayambo	Pisayambo	1977	100 000	H	Tungurahua
Portoviejo	Poza Honda	1968	100 000	I,S	Manabí
	Total Ecuador :		338 000		
(El Salvador)					
Desagüe	Lake Guija	1956	470 000	H	Santa Ana
Lempa	5 de Noviembre	1954	150 000	H	San Salvador
Lempa	Cerrón Grande	1973	1 430 000	H	San Salvador
	Total El Salvador :		2 050 000		
(Guatemala)					
Aguacapa	Agua Caliente	1980	-	H	Santa Rosa
Samala	Santa María	1927	200	H	Quetzaltenango
	Total Guatemala :		200		

Table 9.3 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Panama)					
Bayano	Bayano	1975	4 000 000	H	Panama
Chagres	Madden	1938	624 000	N,H	Panama
El Hato Creek	El Flor	1967	1 400	H	Coclé
Laguna La Yeguada	La Yeguada	1967	14 500	H	Panama
	Total Panamá	:	4 639 900		
	Total - Hydrographic system	:	21 988 480		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Dams for which no reservoir capacity is given are lateral dams not used for water storage.
b/ Symbols used in "Purpose" column:

H: Hydroelectricity
I: Irrigation
N: Navigation
S: Water supply

Table 9.4

TROPICAL PACIFIC HYDROGRAPHIC SYSTEM: HYDROELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Colombia)				
Mayo	Río Mayo	21.0	Nariño	La Union
	Total Colombia :	21.0		
(Costa Rica)				
Torres	La Garita	30.0	San José	San José
	Total Costa Rica :	30.0		
(Ecuador)				
San Pedro	Cumbaya	52.0	Pichincha	Cumbaya
	Total Ecuador :	52.0		
(El Salvador)				
Lempa	Cinco de Noviembre	82.0	Cabañas	Cinco de Noviembre
	Total El Salvador :	82.0		
(Guatemala)				
Michatoya	Jurun Marinala	60.0	Escuintla	Escuintla
	Total Guatemala :	60.0		
(Nicaragua)				
Viejo	General A Somoza	50.0	León	León
	Total Nicaragua :	50.0		
(PanamA)				
Lake Gatún	Gatún	23.0	Panama	Colón
Pacific Ocean	Madden	24.0	Panamá	Panamá
	Total Panamá :	47.0		
	Total - Hydrographic system :	342.0		

Source: ECLAC, on the basis of official data.

Table 9.5

TROPICAL PACIFIC HYDROGRAPHIC SYSTEM: THERMOELECTRIC PLANTS

River or body of water	Name of plant	Capacity (MW)	Administrative division	Locality
(Costa Rica)				
Torres	Colima	20.0	San José	San José
	Total Costa Rica :	20.0		
(Ecuador)				
Guayas	Guayaquil	110.0	Guayas	Ximena
San Pedro	Quito	23.0	Pichincha	Cumbaya
	Total Ecuador :	133.0		
(El Salvador)				
Acelhuate	Soyopango	59.0	San Salvador	Soyopango
Pacific Ocean	Acajutla	70.0	Sonsonate	Acajutla
	Total El Salvador :	129.0		
(Guatemala)				
María Linda	La Laguna	30.0	Guatemala	La Laguna
Michatoya	Escuintla	25.0	Escuintla	Escuintla
Michatoya	Escuintla	33.0	Escuintla	Escuintla
	Total Guatemala :	88.0		
	Total - Hydrographic system :	370.0		

Source: ECLAC, on the basis of official data.

Table 9.6

TROPICAL PACIFIC HYDROGRAPHIC: OIL REFINERIES

River of body of water	Name of refinery	Barrels per day	Administrative division	Locality
(Ecuador)				
Pacific Ocean	Esmeraldas	36 000	Esmeraldas	Esmeraldas
Pacific Ocean	G.La Libertad	8 000	Guayas	La Libertad
	Total Ecuador :	44 000		
(El Salvador)				
Pacific Ocean	Acajutla	17 000	Sonsonate	Acajutla
	Total El Salvador :	17 000		
(Guatemala)				
Michatoya	Texas Petroleum	14 000	Escuintla	Escuintla
	Total Guatemala :	14 000		
	Total - Hydrographic system :	75 000		

Source: ECLAC, on the basis of data compiled by the Latin American Energy Organization (OLADE), 1979.

Table 9.7

TROPICAL PACIFIC HYDROGRAPHIC SYSTEM: PAPER AND PULP INDUSTRIES

River or body of water	Name of industry	Output (tons/year) Pulp	Paper	Locality	Administrative division
(Ecuador)					
Guayas	Papelera Nacional	-	9 000	San Carlos	Guayas
Guayllabamba	Ind. de Papel Arteta	-	700	Quito	Pichincha
	Total Ecuador	-	9 700		
(El Salvador)					
Acelhuate	Cartotecnia	-	8 000	San Salvador	San Salvador
Acelhuate	Fca. de Cartón Hispalia	-	4 800	San Salvador	San Salvador
	Total El Salvador	-	12 800		
(Guatemala)					
Las Vacas	Papeles Elaborados Cía. Ltda.	-	5 300	Guatemala	Guatemala
Michatoya	Ind. Papelera Centroamericana	-	24 000	Escuintla	Escuintla
	Total Guatemala	-	29 300		
(Panama)					
Pacific Ocean	Fca. Interamericana de Papel	-	4 700	Panama	Panama
Pacific Ocean	Industria Panameña de Papel	-	20 000	Panama	Panama
Pacific Ocean	Molino Panameño de Papel	-	3 300	Panama	Panama
	Total Panama	-	28 000		
	Total - Hydrographic system	-	79 800		

Source: ECLAC, on the basis of official data.

Table 9.8

TROPICAL PACIFIC HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

River or body of water	City	Population				Administrative division
		1950	1960	1970	1980	
(Colombia)						
Guevara	Pasto	81 103	82 546	120 298	197 407	Nariño
Pacific Ocean	Buenaventura	54 973	70 079	115 770	160 342	Valle
(Costa Rica)						
Torres	San José	86 909	168 938	211 176	259 126	San José
(Ecuador)						
Guayas	Guayaquil	266 637	515 489	827 490	1 204 532	Guayas
Guayllabamba	Quito	226 547	371 027	624 094	890 355	Pichincha
(El Salvador)						
...	Santa Ana			176 646	417 000	
Acelhuate	San Salvador	161 951	255 744	368 686	915 000	San Salvador
(Panama)						
Pacific Ocean	Panama City	127 874	273 440	411 996	452 000	Panama

Source: Jame W. Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin American Center Publications, University of California, 1981, and ECLAC, on the basis of official data.

Table 9.9

TROPICAL PACIFIC HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960		1970		1980	
		Population	Density	Population	Density	Population	Density
(Colombia) a/							
Cauca	17 585	364 318	20.7	430 113	24.5	477 503	27.2
Chocó	18 612	72 745	3.9	100 489	5.4	97 107	5.2
Nariño	33 268	705 611	21.2	882 389	26.5	1 019 098	30.6
Valle	8 856	693 221	78.3	957 086	108.1	1 138 835	128.6
Total Colombia :	78 321	1 835 896	24.6	2 370 077	32.3	2 732 543	37.4
(Costa Rica) a/							
Alajuela	475	12 034	25.3	16 302	34.3	21 398	45.0
Guanacaste	10 400	142 555	13.7	178 691	17.2	195 208	18.8
Puntarenas	11 311	156 508	13.8	218 208	19.3	265 883	23.5
San José	4 900	487 658	99.5	695 163	141.9	890 434	181.7
Total Costa Rica :	27 086	798 755	28.5	1 108 364	39.3	1 372 923	49.3
(Ecuador) a/							
Azuay	7 701	274 642	35.7	367 324	47.7	442 019	57.4
Bolívar	3 254	139 612	42.9	144 593	44.4	152 101	46.7
Cañar	3 908	112 733	28.8	146 570	37.5	174 510	44.7
Carchi	3 699	94 649	25.6	120 857	32.7	127 779	34.5
Chimborazo	5 637	286 212	50.8	304 316	54.0	341 874	60.6
Cotopaxi	5 287	192 704	36.4	236 313	44.7	277 678	52.5
Esmeraldas	15 216	124 881	8.2	203 151	13.4	249 008	16.4
Guayas	20 902	979 223	46.8	1 512 333	72.4	2 038 454	97.5
Imbabura	4 986	174 039	34.9	216 027	43.3	247 287	49.6
Los Rios	6 254	250 062	40.0	383 432	61.3	455 869	72.9
Manabí	18 400	612 542	33.3	817 966	44.5	906 676	49.3
Pichincha	16 599	587 835	35.4	988 306	59.5	1 382 125	83.3
Tungurahua	2 896	213 932	73.9	279 920	96.7	326 777	112.8
Total Ecuador :	114 739	4 043 066	35.2	5 721 108	49.9	7 122 157	62.1

Table 9.9 (cont.1)

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(El Salvador) a/	18 163	2 176 845	119.9	3 087 144	170.0	3 940 177	216.9
Total El Salvador :	18 163	2 176 845	119.9	3 087 144	170.0	3 940 177	216.9
(Guatemala) a/							
Chimaltenango	198	16 315	82.4	19 438	98.2	23 006	116.3
Escuintla	4 384	270 267	61.6	277 031	63.2	334 666	76.3
Guatemala	2 020	770 315	381.4	1 052 777	521.3	1 245 632	616.7
Jutiapa	3 219	194 774	60.5	233 232	72.5	251 068	78.0
Quetzaltenango	1 951	270 916	138.9	312 787	160.3	366 949	188.1
Retalhuleu	1 856	117 562	63.3	127 235	68.6	150 923	81.3
Santa Rosa	2 955	157 040	53.1	177 159	60.0	194 168	65.7
Solola	74	7 548	101.6	8 909	120.0	10 797	145.4
Suchitepéquez	2 510	186 634	74.4	202 253	80.6	237 554	94.6
Total Guatemala :	19 167	1 991 371	103.4	2 410 820	125.2	2 814 764	146.6
(Honduras) a/							
Choluteca	4 211	149 175	35.4	193 336	45.9	264 328	62.8
El Paraíso	2 165	32 047	14.8	42 238	19.5	56 780	26.2
Francisco Morazán	3 178	113 771	35.8	181 439	57.1	262 508	82.6
Intibuca	1 536	36 569	23.8	40 908	26.6	52 364	34.1
La Paz	1 398	36 360	26.0	39 628	28.3	49 702	35.5
Lempira	2 359	61 350	26.0	70 280	29.8	90 248	38.3
Ocotepeque	840	26 270	31.3	25 519	30.4	31 077	37.0
Valle	1 565	80 907	51.7	91 901	58.7	117 909	75.3
Total Honduras :	17 254	536 449	28.4	685 248	37.3	924 914	50.8
(Nicaragua) a/							
Carazo	1 097	65 888	60.1	71 810	65.5	92 326	84.2
Chinandega	4 789	128 624	26.9	158 210	33.0	264 034	55.1
León	5 243	150 051	28.6	166 270	31.7	246 348	47.0
Managua	1 179	111 589	94.7	168 910	143.3	288 783	245.0
Rivas	2 190	64 361	29.4	75 630	34.5	96 417	44.0
Total Nicaragua :	14 498	520 513	43.6	640 830	57.2	987 908	91.3

Table 9.9 (concl.)

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
(Panama) a/							
Chiriquí	8 758	188 350	21.5	236 154	27.0	287 350	32.8
Coclé	5 035	93 156	18.5	118 003	23.4	140 903	28.0
Darién	16 803	19 715	1.2	22 685	1.4	26 524	1.6
Herrera	2 427	61 672	25.4	72 549	29.9	81 963	33.8
Los Santos	3 867	70 554	18.2	72 380	18.7	70 261	18.2
Panama	11 292	372 393	33.0	576 645	51.1	831 048	73.6
Veraguas	11 086	131 685	11.9	151 849	13.7	173 245	15.6
Total Panama :	59 268	937 525	15.8	1 250 265	21.1	1 611 294	27.2
Total - Hydrographic system :	348 495	12 840 420	35.6	17 273 856	47.9	21 506 679	59.8

Source: Organization of American States (OAS) and Inter-American Statistical Institute (IASI), América en cifras, 1974. Situación demográfica: estado y movimiento de la población, Washington D.C., OAS General Secretariat, 1974, and national censuses.

Note: The figures appearing under the headings 1960, 1970 and 1980 actually correspond to the census dates given for each country.

a/ Dates of censuses: Colombia: 15-07-64, 24-10-73, 1985; Costa Rica: 31-03-63, 14-05-73, 10-06-84; Ecuador: 25-11-62, 08-06-74, 28-11-82; El Salvador: 02-05-61, 28-06-71, 31-12-78 (estimates as of date shown); Guatemala: 18-04-64, 26-03-73, 26-03-81; Honduras: 17-04-61, 06-03-74, 30-06-80 (estimates as of date shown); Nicaragua: 25-04-63, 20-04-71, estimates; Panama: 11-12-60, 10-05-70, 11-05-80.

X. CARIBBEAN ISLAND HYDROGRAPHIC SYSTEM

A. GEOGRAPHY OF THE AREA

1. Introduction

This hydrographic system is composed of numerous islands of varying sizes which together make up the Caribbean island region. It covers a total area of 230 789 km^2 and extends in the form of an arc from Florida in the United States and the Yucatán Peninsula of Mexico in the north down to the north-east coast of Venezuela. The entire Caribbean region lies between 12° and 27° north latitude and between 60° and 85° west longitude. The largest islands are concentrated in the north-western portion of the region (Greater Antilles) and account for more than 80% of its total land area (Cuba: 105 007 km^2, Hispaniola (Haiti and Santo Domingo): 76 286 km^2, Jamaica: 11 428 km^2, Puerto Rico: 8 780 km^2 and Andros (the Bahamas): 5 956 km^2). The Lesser Antilles are situated in the eastern and south-eastern portions of the region between the island of Puerto Rico and the Gulf of Venezuela. The largest island in this part of the hydrographic system is Trinidad, which has an area of approximately 4 828 km^2 (see map 10.1).

2. Climate

a) Climate types (Köppen classification): Most of the Caribbean islands are located within the intertropical convergence zone to the south of the Tropic of Cancer, where various types of tropical climates predominate. The most influential climatic factors are the permanent anti-cyclone in the north Atlantic and the warm ocean currents flowing up from the Equator. Both of these factors give rise to high temperatures on the land areas within their sphere of influence.

The cyclones that form in the south-eastern part of the Caribbean and in the southern portion of the north Atlantic, and which then move towards the north-west along a parabolic trajectory, have a particularly strong effect on the weather. These cyclones occur mainly during the autumn (September and October) and bring heavy rains and strong winds.

The regional and local variations in climate are chiefly due to differences in the altitude of the terrain (mountains and mountain chains).

The predominant climates in the Caribbean islands are tropical savanna (Aw), tropical rainforest or monsoon (Am) and tropical jungle climates (Af). The wettest climates (Af and Am) are mainly found to be windward side of the Atlantic anti-cyclone along the northern coasts of the islands.

b) Precipitation: Throughout the Caribbean region precipitation is concentrated in the summer months (May to October) and occurs in the form of monsoons (short, intense downpours) in the tropical rainforest zones (Am).

In Cuba, mean annual precipitation varies between 800 and 2 200 mm, with the highest means being found in the Sierra Trinidad and the Sierra Maestra, and the lowest means occurring in the area around Guantánamo Bay and in Nipe Bay.

In Hispaniola, mean annual precipitation is 1 400 mm, most of which occurs in 110 days out of the year. The highest annual means are over 2 000 mm and are concentrated in the mountainous zones along the border between Haiti and the Dominican Republic.

On the island of Puerto Rico, mean annual precipitation is nearly 2 000 mm on the northern slope of the central mountain range. On the southern slope, the annual mean falls to 1 500 mm.

In Jamaica, mean annual precipitation is 1 980 mm, with local variations being observed between the northern and southern slopes of the mountain chain which, although it breaks off in some places, crosses the island from east to west. The moisture-laden north-easterly Trade Winds bring between 3 000 and 6 000 mm of rain annually to the northern slope. These winds create a rain shadow on the southern slope, which receives only 1 500 mm of rainfall per year. The periods of heaviest rainfall during the year (the greatest amount of rain falls in October and there is a less intense rainy season in May) occur when the intertropical convergence zone shifts southward and when it moves back in the opposite direction.

Mean annual precipitation is generally less than 1 500 mm in the smaller islands, such as the Bahamas and the Netherlands Antilles, and over 2 000 mm in the mountainous islands.

c) Temperature: The entire Caribbean area has high temperatures, with annual means in excess of 25°C. The mean monthly temperatures during the coldest months (January and February) and in the highest areas do not drop below 18°C.

Variations in mean monthly temperatures during the year are less than 4°C and diminish as one moves towards the Equator.

On the islands of Cuba, Hispaniola and Puerto Rico, mean temperatures range from 18° to 28°C depending upon the season and altitude. The variation is slightly less in Jamaica due to its greater proximity to the Equator.

In Barbados, temperatures fluctuate between 26° and 31°C during the rainy season (June to November) and between 19° and 30°C during the dry season (February to April) (see table 10.1).

3. Geomorphology and soils

Most of the Caribbean islands are part of the great Antilles/Caribbean arc which runs from the Yucatán Peninsula on the west to the islands of Trinidad and Tobago off the Venezuelan coast and beyond to the island of Aruba near the Gulf of Venezuela.

This great arc corresponds to a geo-anticline whose upper reaches break through the surface to form the group of islands which make up the Caribbean region, i.e., the Greater Antilles and the Lesser Antilles. The geological features of the islands vary a great deal. In the Greater Antilles cluster, igneous rocks make up the basal complex (early Mesozoic), and this complex is covered by Cretacean sediments (late Mesozoic) of volcanic and marine detritus origin (Puerto Rico and the Virgin Islands). In many areas Cainozoic sediments predominate, most of which are calcareous (karst). Alluvial quaternary formations of sandstone and coral also abound in the coastal zones.

Some islands are composed almost exclusively of karst, including Anguilla, Bahamas, Barbados, Barbuda, Bonaire, the Cayman Islands, Grande Terre, María Galante, Saint Martin and the Venezuelan Antilles.

Other islands are composed chiefly of volcanic formations, such as Aruba, Basseterre, Curacao, Dominica, Grenada, the Grenadines, Montserrat, Nevis, Saba, Saint Kitts, Saint Eustatius, Saint Lucia and Saint Vincent.

Two clearly differentiated slopes exist on the four largest islands (Cuba, Hispaniola, Jamaica and Puerto Rico). The northern islands differ from those further south in that they contain a discontinuous E-W mountain chain which reaches altitudes of nearly 2 000 m above sea level at its highest points.

In the case of Cuba, 71% of the island's surface area is between 100 and 600 m above sea level; 24% is below 100 m and 5% is between 600 and 2 000 m above sea level. The geomorphology of the island ranges from extensive, mildly-sloping plains and

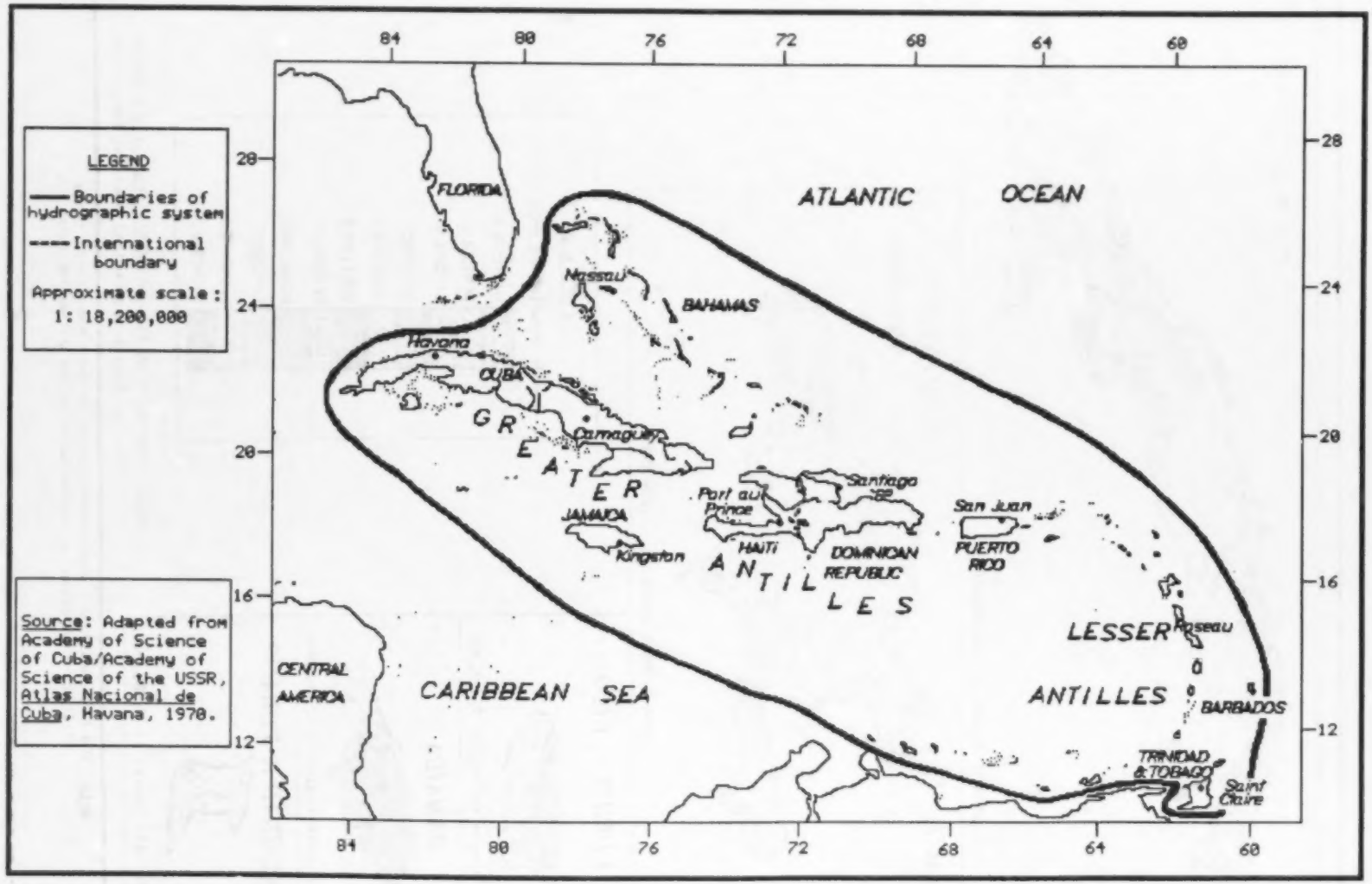
lowlands to higher land or mountain ranges in the west (the Guaniguanico range), in the central portion of the island (the Guamuhaya massif) and in the east (the Sierra Maestra). Cuba is characterized by marked and widespread karstian phenomena. Large areas are made up of calcareous rocks (limestone) of various types and ages in the submerged and emergent coastal plains and, indeed, throughout the entire territory with the exception of the mountainous zones. In the mountains, metamorphic and igneous rocks predominate, interspersed with sandstone and limestone.

The orographic system of the island of Hispaniola consists of five mountain chains running NW-SE which cover 60% of the entire territory. This is a complex system which includes both the highest point in the Antilles (the Pico Duarte in the Dominican Republic, at 3 175 m above sea level) and the lowest (Lake Enriquillo, also in the Dominican Republic, which is 40 m below sea level). The remaining 40% of the island consists of valleys running in the same direction as the mountain chains. Calcareous sedimentary rock and volcanic rock predominate in the central and eastern mountain ranges.

In Jamaica, the central mountain chain, which runs in a generally WNW-ESE direction, is chiefly made up of volcanic formations and covers approximately 25% of the island's surface. In the central portion of the island this mountain chain gives way to high plains (approximately 600 metres above sea level) of karstic origin (calcareous rocks). These karstic formations cover about 60% of the island. The remainder is composed of the alluvial soils found in the valleys and coastal plains.

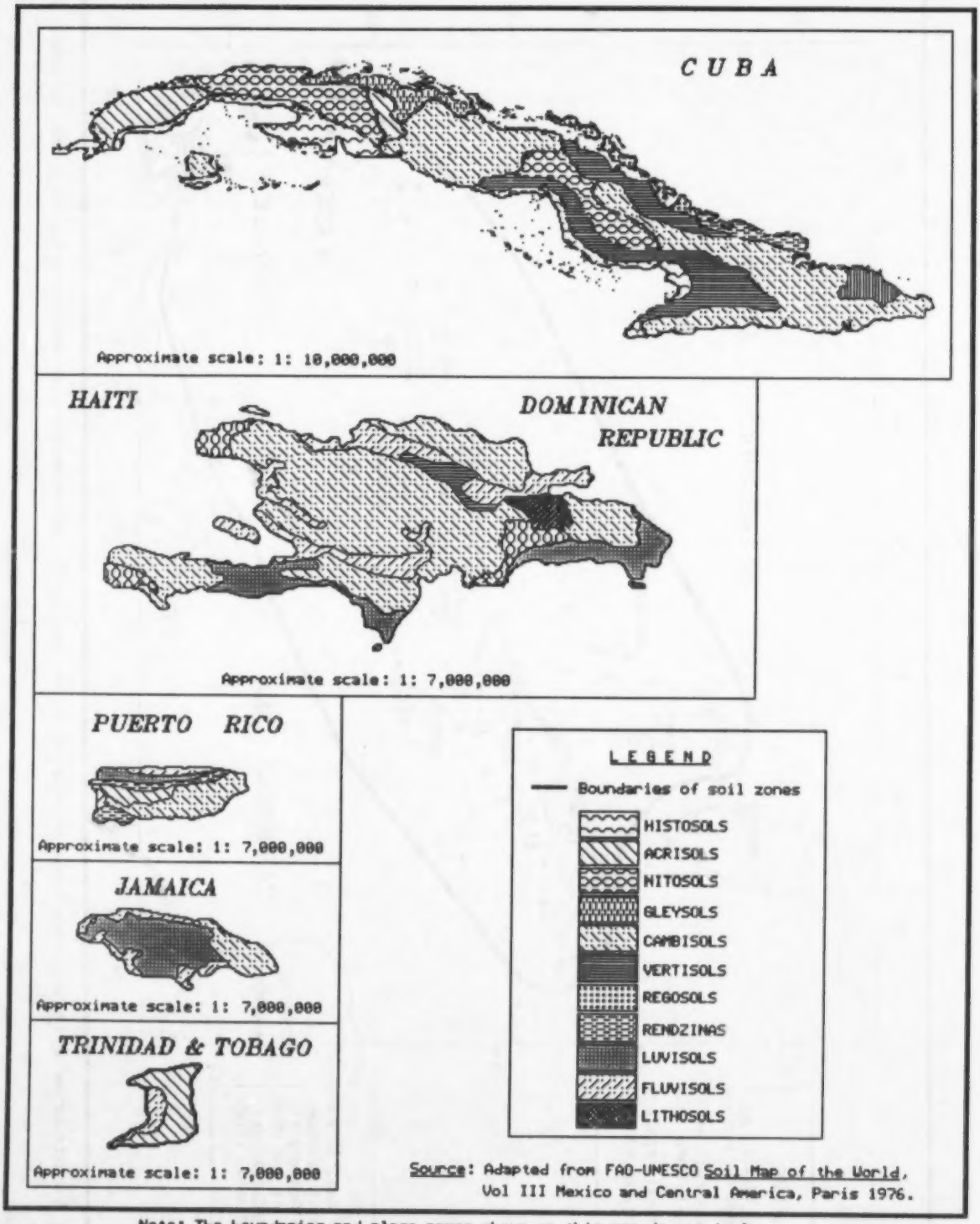
The main physiographic characteristic of the island of Puerto Rico is the central mountain range, which stretches for 100 km in an E-W direction. Near the southern coast of the island it reaches maximum altitudes of 1 300 m above sea level. This central mountain system is formed by heavily folded and metamorphosed intrusive volcanic rock. Sedimentary deposits are present all along the northern and southern slopes and are found in combination with thick strata of limestone as one nears the coast. These calcareous strata are up to 1 000 m thick at the coast and 800 m thick in the southern coastal plains.

The most productive soils in terms of natural fertility, good drainage and depth are, in decreasing order, the nitosols, the luvisols and fluvisols, the acrisols, the cambisols and vertisols. On the other hand, in the group of soils with drainage problems and/or insufficient fertility are the gleysols, histosols, regosols, ferrasols and litosols. The rendzina soils are fertile and well drained. Their productivilty depends more of the seasonality of the rainfall and the existing ploughing facilities (see map 10.2).



Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Map 10.2



Source: Adapted from FAO-UNESCO Soil Map of the World, Vol III Mexico and Central America, Paris 1976.

Note: The boundaries and place names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 10.1

CARIBBEAN ISLAND HYDROGRAPHIC SYSTEM: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION AND TEMPERATURES AT SELECTED CITIES (SEE MAP 10.1)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
KINGSTON, Jamaica (88)												
17°59′N-76°48′W												
Altitude: 24 m												
mmp (map: 800 mm)	22	20	22	30	86	89	43	102	100	174	79	33
mmt (mat: 26.3°C)	24.9	24.7	25.2	25.9	26.7	27.4	27.7	27.6	27.5	26.6	26.3	25.6
Climate: Aw												
SANTIAGO,Dominican Republic (23)												
19°27′N-70°42′W												
Altitude: 222 m												
mmp (map: 950 mm)	60	48	42	77	180	67	51	64	100	95	98	70
mmt (mat: 26.0°C)	23.4	23.9	25.1	26.4	26.5	27.2	27.4	27.9	27.6	27.0	25.8	24.1
Climate: Aw												
LA HABANA, Cuba (116)												
23°09′N-82°22′W												
Altitude: 50 m												
mmp (map: 1 136 mm)	62	39	50	52	104	146	105	108	150	184	84	52
mmt (mat: 24.7°C)	21.8	22.1	23.1	24.4	25.6	26.5	26.9	27.2	26.8	25.4	23.6	22.3
Climate: Aw												
NASSAU, Bahamas (110)												
25°03′N-77°28′W												
Altitude: 3 m												
mmp (map: 1 252 mm)	42	40	35	63	126	176	151	159	183	168	70	39
mmt (mat: 24.3°C)	20.3	20.9	22.2	23.6	25.2	26.7	27.4	27.7	27.1	25.5	23.5	21.6
Climate: Aw												
PUERTO PRINCIPE, Haiti (85)												
18°33′N-72°70′W												
Altitude: 134 m												
mmp (map: 1 340 mm)	32	53	83	162	229	99	74	146	173	168	85	36
mmt (mat: 26.3°C)	24.5	25.4	25.6	26.3	26.7	27.6	28.0	27.7	26.7	26.6	25.9	24.0
Climate: Aw												
CAMAGUEY, Cuba (30)												
21°25′N-77°51′W												
Altitude: 118 m												
mmp (map: 1 385 mm)	30	37	55	86	180	230	134	170	187	170	69	37
mmt (mat: 25.2°C)	22.0	23.0	24.5	25.3	26.1	26.7	27.3	27.6	26.9	25.9	24.0	22.6
Climate: Aw												

Table 10.1 (concl.)

City a/ b/ c/	Months d/											
	J	F	M	A	M	J	J	A	S	O	N	D
SAN JUAN, Puerto Rico (62)												
18°28'N-66°07'W												
Altitude: 14 m												
mmp (map: 1 531 mm)	106	69	69	101	159	139	150	158	155	138	162	131
mmt (mat: 25.6°C)	23.9	23.9	24.2	24.9	26.0	26.6	26.7	27.0	27.0	26.7	25.8	24.7
Climate: Af												
ROSEAU, Dominica (67)												
15°18'N-61°23'W												
Altitude: 18 m												
mmp (map: 1 970 mm)	130	81	75	71	101	196	275	251	228	201	205	155
mmt (mat: 26.2°C)	24.4	24.4	25.1	25.8	27.2	27.3	26.8	27.1	27.3	27.1	26.4	25.1
Climate: Af												
SAINT CLAIR, Trinidad and Tobago (99)												
10°40'N-61°31'W												
Altitude: 20 m												
mmp (map: 1 627 mm)	67	40	45	53	93	193	216	247	193	170	183	126
mmt (mat: 26.3°C)	25.5	25.5	25.8	26.4	27.1	26.6	26.4	26.5	26.7	26.8	26.5	25.9
Climate: Aw												

Source: United Nations Food and Agriculture Organization (FAO), Datos Agroclimatológicos para América Latina y el Caribe, Rome, 1985.

a/ The number in parentheses beside the name of the country indicates the length of time such records have been kept, in years.

b/ The meanings of the abbreviations used in this column are:
- Af : tropical jungle climate
- Aw : tropical rainforest climate
- map: mean annual precipitation
- mmp: mean monthly precipitation
- mat: mean annual temperature
- mmt: mean monthly temperature

c/ Cities are listed in ascending order of mean annual precipitation (map).

d/ Mean monthly precipitation (mmp) is expressed in millimetres (mm). Mean monthly temperatures (mmt) are expressed in Centigrade degrees (°C).

B. STATISTICAL DATA CONCERNING WATER USE

At the time of publication, information was not available on hydroelectric plants, thermoelectric plants, oil refineries, iron and steel industries, paper and pulp industries or non-ferrous metals industries in this hydrographic system.

Table 10.2

DAMS IN THE CARIBBEAN ISLAND HYDROGRAPHIC SYSTEM

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Cuba)					
Agabama	Agabama	1948	4 000	S	Las Villas
Almendares	Ejército Rebelde	1972	52 000	C	Havanna
Arroyo Hondo	Clotilde	1971	6 000	I	Eastern
Arroyo Luis	El Enlace	1972	19 000	I	Havana
Arroyo Luz	Mampostón	1973	155 000	I	Havana
Arroyo Montecitos	Montecitos	1969	3 200	I	Camaguey
Arroyo Pontezuela	Pontezuela	1932	7 000	S	Camaguey
Arroyo Santa Rita	Tacajo	1971	12 000	S	Eastern
Bacuranao	Bacuranao	1971	14 600	I	Havana
Banes	La Coronela	1973	13 300	I	Havana
Buey	Bueycito	1973	155 300	I	Eastern
Cacoyoguín	Cacoyoguín	1953	5 700	S	Eastern
Canasi	Canasi	1972	58 000	I	Havana
Caonao	Caonao	1969	27 800	S,I	Camagüey
Cauto	Gilbert	1967	42 500	S	Eastern
Concepción	Mañana de la Santa Ana	1967	38 100	S	Camagüey
Contramaestre	Carlos Manuel de Céspedes	1967	200 600	I	Eastern
Cristal	Cristal	1969	6 750	I	Havana
Del Medio Las Nuevas	Del Medio-Las Nuevas	1971	44 500	I	Havana
Guaimaro	Guaimaro	1967	3 640	S	Camagüey
Guanabo	La Coca	1968	11 800	S	Havana
Guanabo	La Zarza	1971	17 400	S	Havana
Guantánamo	La Yaya	1973	160 000	I	Eastern
Guayabo	Antonio Briones Montoto	1968	4 500	I	Havana
Hanabanilla	Hanabanilla	1960	286 000	H,S,I	Las Villas
Hanabanilla	Paso Bonito	1973	3 800	I,S	Las Villas
Hondo	Ramirez	1972	2 218 100	I	Pinar del Río
Jatibonico del Sur	Paso Lebrije	1972	100 000	I	Las Villas
Jibacoa	Jibacoa	1972	7 660	I	Havana
Las Nuevas	Viet Nam Heroico	1966	42 500	I	Havana
Los Indios	Los Indios I	1970	9 200	I	Havana
Mabay	Pedregal	1972	39 800	I	Eastern
Mal País	Mal País I	1970	13 000	I	Havana
Matamoros	Guirabo	1969	15 200	I	Eastern

Table 10.2 (cont.1)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Cuba)					
Mayareque	Pedroso	1973	4 870	I	Havana
Mosquito	Mosquito	1965	3 800	S	Havana
Nipe	Sabanilla	1972	30 600	I	Eastern
Nipe	Nipe	1973	112 000	I	Eastern
Sagua La Chica	Minerva	1971	123 000	I	Las Villas
Sagua La Grande	Alacranes	1972	365 000	I	Las Villas
San Diego	Juventud	1972	105 000	I	Pinar del Río
San Pedro	Jimaguayu	1972	200 000	I	Camagüey
Santa Ana	Maurín	1972	17 550	I	Havana
Santa Cruz	Hidráulica Cubana	1970	42 000	I	Camagüey
Santa Cruz	Niña Bonita	1972	5 740	I	Havana
Santa Fe	La Fe	1972	32 400	I	Havana
Taguasco	Siguaney	1968	9 300	S	Las Villas
Yara	Paso Malo	1967	86 100	I	Eastern
Zaza	Zaza	1972	1 020 000	I	Las Villas
	Total - Cuba	:	5 955 310		
(Haiti)					
Artibonite	Barrage de Peligre	1955	620	I,H,C	Dpmt.du Centre
	Total - Haití	:	620		
(Jamaica)					
Hope River	Mona	1947	3 787	S	Kingston/St. Andrew
Wag Water	Hermitage	1927	1 636	S	Kingston/St. Andrew
	Total - Jamaica	:	5 423		
(Dominican Republic)					
Bao	Tavera-Bao	1980	280 000	I,H,S	Santiago
Chacuey	Chacuey	1979	19 300	I	Monte Cristi
Jima	Rincón	1978	74 500	I,H,S	La Vega
Maguaca	Maguaca	1979	13 000	I	Monte Cristi
Nizao	Valdesia	1975	187 000	I,H	Peravia
San Juan	Sabaneta	1980	78 000	I,H	San Juan
Yaque del Norte	Tavera	1974	170 000	I,H	Santiago
Yaque del Sur	Sabana Yegua	1978	677 000	I,H,C	San Juan
Yuna	Hatillo	1981	700 000	I,H,C	Sánchez Ramírez
	Total - Dominican Republic	:	2 198 800		

Table 10.2 (concl.)

River or body of water	Name of dam	Year built	Reservoir capacity (thousands of m3) a/	Purpose b/	Administrative division
(Trinidad and Tobago)					
...	Hollis	1936	4 500		Trinidad and Tobago
...	Hillsborough	1952	1 000		Trinidad and Tobago
...	Navet	1962	-		Trinidad and Tobago
Arena	Arena	1982	42 000		Trinidad and Tobago
	Total - Trinidad and Tobago:		47 500		
	Total - Hydrographic system :		8 207 653		

Source: International Commission on Large Dams (ICOLD), World Register of Dams, Paris, 1984.

a/ Dams for which no reservoir capacity is given are lateral dams.

b/ Symbols used in "Purpose" column:
C: Flood control
H: Hydroelectricity
I: Irrigation
S: Water Supply.

Table 10.3

CARIBBEAN ISLAND HYDROGRAPHIC SYSTEM: CITIES HAVING POPULATIONS OVER 100 000 AS OF 1980

River or body of water	City	Population				Administrative division
		1950	1960	1970	1980	
(Cuba)						
Almendares	Havanna	1 139 579		1 786 522	1 929 432	Havanna
Bahía Cienfuegos	Cienfuegos	57 991		80 758	102 791	Las Villas
Bayamo	Bayamo	26 098		71 484	100 622	Eastern
Holguín	Holguín	58 776		131 656	186 943	Eastern
Caribbean Sea	Guantánamo	64 671		129 005	167 255	Eastern
Caribbean Sea	Santiago de Cuba	163 237		277 600	351 241	Eastern
Sagua La Grande	Santa Clara	77 398		130 241	173 397	Las Villas
San Pedro	Camagüey	110 388		197 720	245 525	Camagüey
Yumuri/San Juan	Matanzas	63 916		86 596	100 831	Matanzas
(Haiti)						
Bois de Chene	Puerto Príncipe	134 117		493 932	...	Western
(Jamaica)						
Caribbean Sea	Kingston	...	376 500	550 000	650 000	Kingston Metropolitan Area
(Puerto Rico)						
Cidra	Bayamón	20 171	15 109	147 552	208 600	...
Laguna de San José	San Juan	224 767	432 377	452 749	1 022 000	...
Loiza	Caguas	33 759	32 015	63 215	117 600	...
Caribbean Sea	Ponce	99 492	114 286	128 293	158 981	...
(Dominican Republic)						
Ozama	Santo Domingo	181 553	369 980	673 470	1 170 463	National District
Yaque del Norte	Santiago de Los Caballeros	56 558	85 640	155 000	253 375	Santiago

Source: James W. Wilkie and Stephen Haber (eds.), Statistical Abstract of Latin America, vol. 21, Los Angeles, UCLA Latin American Center Publications, University of California, 1981, and ECLAC, on the basis of official figures.

Table 10.4

CARIBBEAN ISLAND HYDROGRAPHIC SYSTEM: DEMOGRAPHIC DATA BY ADMINISTRATIVE DIVISION

Administrative division	Area (km2)	1960		1970		1980	
		Population	Density	Population	Density	Population	Density
Antigua	280	55 000	196.4	66 000	235.7	75 000	267.9
Total - Antigua :	280	55 000	196.4	66 000	235.7	75 000	267.9
(French Antilles)							
Guadalupe	1 433	275 000	191.9	320 000	223.3	318 000	221.9
Martinica	1 030	285 000	276.7	325 000	315.5	312 000	302.9
Total - French Antilles :	2 463	560 000	227.4	645 000	261.9	630 000	255.8
Netherlands Antilles	800	192 000	240.0	222 000	277.5	247 000	308.8
Total - Netherland Antilles :	800	192 000	240.0	222 000	277.5	247 000	308.8
Bahamas	13 294	113 000	8.5	171 000	12.9	210 000	15.8
Total - Bahamas :	13 294	113 000	8.5	171 000	12.9	210 000	15.8
Barbados	430	231 000	537.2	239 000	555.8	254 000	590.7
Total - Barbados :	430	231 000	537.2	239 000	555.8	254 000	590.7
Bermuda	54	45 000	833.3	55 000	1 018.5	71 000	1 314.8
Total - Bermuda :	54	45 000	833.3	55 000	1 018.5	71 000	1 314.8
Colombian islands	42	...	...	...	...	41 415	986.1
Total - Colombian islands :	42	...	...	...	...	41 415	986.1
Cuba	107 240	7 077 190	66.0	8 569 121	79.9	9 942 121	92.7
Total - Cuba :	107 240	7 077 190	66.0	8 569 121	79.9	9 942 121	92.7
Dominica	750	60 000	80.0	71 000	94.7	73 000	97.3
Total - Dominica :	750	60 000	80.0	71 000	94.7	73 000	97.3

Table 10.4 (cont.1)

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
Grenada	345	90 000	260.9	94 000	272.5	107 000	310.1
Total Grenada :	345	90 000	260.9	94 000	272.5	107 000	310.1
Haiti	27 750	3 723 000	134.2	4 314 628	155.5	5 809 000	209.3
Total Haiti :	27 750	3 723 000	134.2	4 314 628	155.5	5 809 000	209.3
British Virgin Islands	127	7 000	55.1	10 000	78.7	12 000	94.5
Total - British Virgin Islands :	127	7 000	55.1	10 000	78.7	12 000	94.5
US Virgin Islands	342	33 000	96.5	64 000	187.1	98 000	286.5
Total - US Virgin Islands :	342	33 000	96.5	64 000	187.1	98 000	286.5
Cayman Islands	258	9 000	34.9	10 000	38.8	17 000	65.9
Total - Cayman Islands :	258	9 000	34.9	10 000	38.8	17 000	65.9
Jamaica	11 428	1 642 400	143.7	1 848 508	161.8	2 095 000	183.3
Total - Jamaica :	11 428	1 642 400	143.7	1 848 508	161.8	2 095 000	183.3
Montserrat	102	12 000	117.6	12 000	117.6	12 000	117.6
Total - Montserrat :	102	12 000	117.6	12 000	117.6	12 000	117.6
Puerto Rico	8 992	2 358 000	262.2	2 754 000	306.3	3 187 590	354.5
Total - Puerto Rico:	8 992	2 358 000	262.2	2 754 000	306.3	3 187 590	354.5

Table 10.4 (concl.)

Administrative division	Area (km2)	1960 Population	1960 Density	1970 Population	1970 Density	1980 Population	1980 Density
Dominican Republic	48 442	3 047 070	62.9	4 010 998	82.8	5 621 985	116.1
Total - Dominican Republic :	48 442	3 047 070	62.9	4 010 998	82.8	5 621 985	116.1
Saint Lucia	616	88 000	142.9	101 000	164.0	120 000	194.8
Total Saint Lucia :	616	88 000	142.9	101 000	164.0	120 000	194.8
Saint Vincent	...	80 000	...	88 000	...	99 000	...
Total - Saint Vincent	...	80 000	...	88 000	...	99 000	...
Saint Kitts and Nevis	266	57 000	214.3	52 000	195.5	52 000	195.5
Total - Saint Kitts and Nevis :	266	57 000	214.3	52 000	195.5	52 000	195.5
Trinidad and Tobago	5 128	843 000	164.4	1 027 000	200.3	1 068 000	208.3
Total - Trinidad and Tobago :	5 128	843 000	164.4	1 027 000	200.3	1 068 000	208.3
Turks and Caicos	476	6 000	12.6	6 000	12.6	7 000	14.7
Total - Turks and Caicos :	476	6 000	12.6	6 000	12.6	7 000	14.7
Venezuelan Antilles	1 164	...	...	...	...	195 300	167.8
Total - Venezuelan Antilles :	1 164	...	...	...	...	195 300	167.8
Total - Hydrographic system :	230 789	20 328 660	88.1	24 430 255	105.9	30 044 411	130.2

Source: United Nations, World Population Prospects: Estimates and Projections as Assessed in 1982 (ST/ESA/SER.A/86), New York, 1985, United Nations Publication, Sales No. E.83.XIII.5.

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